THE INSTITUTION OF PRODUCTION ENGINEERS

JOURNAL
(March, 1946, Vol. XXV, No. 3, Ed. A)

Contents:

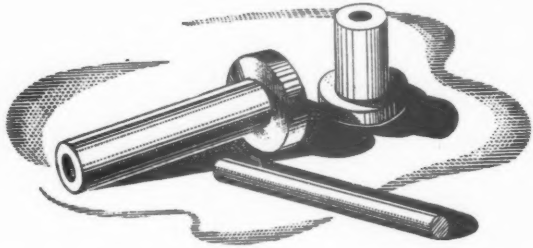
DIFFICULTIES AND DEVELOPMENTS IN DEEP DRAWING AND PRESSING

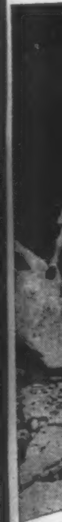
by

J. D. JEVONS, Ph.D., B.Sc., F.R.I.C., F.I.M.

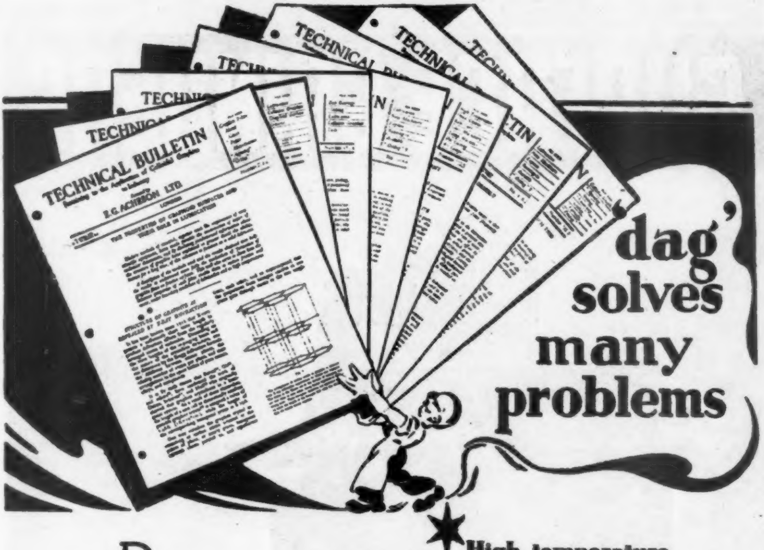
PUBLISHED BY THE INSTITUTION
36, PORTMAN SQUARE, LONDON, W.1

PRICE 5/-





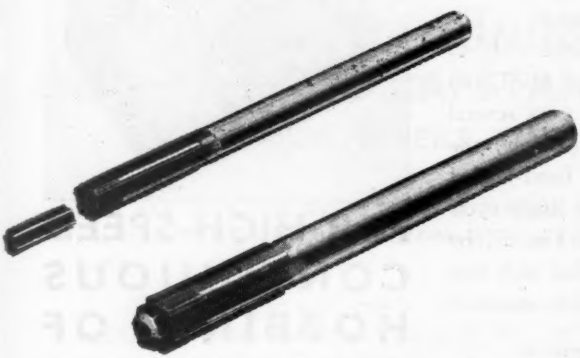

PARKSON
Mills
No. 3J
UNIVERSAL MILLER
with
* DAVIT ON OVERARM
and
* ROTARY TABLE
* FOR HAND AND POWER FEED
PARKSON
J. PARKINSON & SON Shipley Yorks


TECHNICAL BULLETIN
E.G. ACHESON LTD
'dag'
solves
many
problems


PRESSURE
DIE CASTINGS
WOLVERHAMPTON
DIE-CASTING Cº Lᵀᴰ
GRAISELEY HILL
WOLVERHAMPTON
IN ZINC ALLOY—
"MAZAK" OF COURSE!
TELEGRAMS: DIECASTINGS, WOLVERHAMPTON.
TELEPHONE W'TON 23831/4

WIMET TIPPED EXPANSION REAMERS

IN STOCK



We have in stock for in. mediate delivery Wim(Tipped expansion reame: wi h straight or tape shanks. These are availab in sizes from ⅜" to 1" di Other sizes quoted c application.

The exclusive features are

Positive support to the cu ting edges.

No screws to vibrate loos

Uniform and parallel e pansion for entire leng of the cutting portion the blade.

Adequate clearance mai tained throughout expa sion.

These features are availat only in the Wickman Pate Expansion Reamers, whi are fully covered by pater

A.C. Wickma LIMITED
COVENTRY • ENGLAND

LONDON . BRISTOL . BIRMINGHAM . MANCHESTER . LEEDS . GLASGOW . NEWCAST

THE INSTITUTION OF PRODUCTION ENGINEERS

Members' Luncheon, 1946

It has been possible this year to arrange an ***Institution Luncheon***, which will take place at the ***Dorchester Hotel***, Park Lane, London, W.1., on ***Friday***, ***May 17th.***

Owing to catering difficulties, the number of seats for luncheon is strictly limited, and it is regretted that on this occasion it is impossible to make arrangements for the entertainment of Members' guests.

Applications for tickets should be made on the form below as early as possible.

To :
The Director-General Secretary,
The Institution of Production Engineers,
10, Seymour Street,
London, W.1.

Please forward ticket(s) at 30/- (thirty shillings) each for the Members' Luncheon, for which I enclose my cheque/postal order/ money order for the sum of £ s. d.

Name :..

Address :..

....

Grade of Membership :..

If the application is for more than one ticket, please furnish Names and Grade(s) of Membership in respect of all tickets.

Cheques, postal orders, or money orders should be crossed and made payable to the Institution of Production Engineers.

The Council of the Institution

1946-47

President
SIR ROBERT MCLEAN

President-Elect
N. Rowbotham, C.B.E.

Chairman of Council
J. E. BLACKSHAW

Vice-Chairman
Dr. H. Schofield, M.B.E.

Past Presidents

Sir George E. Bailey, C.B.E.
Sir Ernest J. H. Lemon, O.B.E.
The Rt. Hon. Viscount Nuffield, G.B.E.
J. D. Scaife.

Vice-Presidents

Sir Norman V. Kipping, H. A. Hartley, T. Fraser, J. G. Young

Section Presidents

B. Newbold .... *Coventry*
F. C. White .... *Birmingham*
A. L. Stuchbery .... *London*
E. J. Piggott .... *Luton*
F. Osborne .... *Manchester*
M. Steven Dick .... *Glasgow*
R. E. Dunnett .... *E. Counties*
J. E. Hill .... *Yorkshire*
Alan Moncrieff, O.B.E. .... *Sheffield*
F. H. Moorman, M.B.E. ...... *Western*
G. H. Allen .... *Southern*
J. Pollard .... *Leicester*
L. C. Row .... *Preston*
G. W. Bradshaw .... *Edinburgh*
S. D. McPhee .... *Sydney*
W .G. Bennetts .... *Cornwall*
A. Johnstone .... *Nottingham*
C. S. Noble .... *N. Eastern*
W. Allen .... *N. Ireland*
Hon. O. M. Guest *South Wales and Mon.*
F. Glover .... *Melbourne*
E. W. Hancock, M.B.E. *Wolverhampton*
W. P. Eastwood .... *Halifax*

Additional Section Representatives

F. W. Halliwell .... *London*
G. H. Hales .... *London*
F. W. Cranmer .... *Manchester*
E. P. Edwards .... *Birmingham*
J. W. Berry .... *Birmingham*
F. A. Pucknell........... ...*Manchester*
Dr. W. A. J. Chapman...... *Wolverhampton*

Chairmen of Standing Committees

The Rt. Hon. Lord Sempill, A.F.C.
Alastair McLeod
J. T. Kenworthy

Ordinary Members

R. M. Buckle, J. S. Daniels, W. F. Dormer, H. A. Drane, H. J. Gibbons, E. J. H. Jones, M.B.E., Mark H. Taylor, T. Thornycroft, H. F. Beaumont, G. R. Pryor, R. Kirchner.

Director-General Secretary
Major C. B. Thorne, M.C.

Section Honorary Secretaries

Birmingham: A. J. Mansell, 204, Alcester Road South, Birmingham, 14.
Cornwall: H. A. Kench, "Rokeby," Illogan, nr. Redruth, Cornwall.
Coventry: R. R. Brittain, 65, Holborn Avenue, Holbrooks, Coventry.
Derby Sub-Section: H. A. Hirst, "Tresayes," 19, Rosamond's Ride, Littleover, Derby.
Eastern Counties: L. A. Child, Crane Ltd., Nacton Road, Ipswich.
Edinburgh: J. L. Bennett (Acting), Alder & Mackay, Ltd., New Grange Works, Edinburgh.
Glasgow: W. P. Kirkwood, "Morar," Sandfield Avenue, Milngavie, Dumbartonshire.
Halifax: A. Mitchell, John Stirk & Sons, Ovenden Road, Halifax.
Leicester and District: H. S. Burdett, 29, Northcote Road, Leicester.
Lincoln Sub-Section: R. Preston, 9, Hunt Lea Avenue, Lincoln.
London: B. H. Dyson, Hoover Ltd., Perivale, Greenford, Middx.
Luton and Bedford: R. M. Buckle, 238, Cutenhoe Road, Luton.
Manchester: F. W. Cranmer, Associated British Machine Tool Makers, Ltd., Lloyds Bank Buildings, King Street, Manchester.
Melbourne (Victoria, Aus.): C. Pullen, 13, Immarna Road, Camberwell, E.6.
North Eastern: J. Nicod, A. Reyrolle & Co., Ltd., Hebburn-on-Tyne, Co. Durham.
Northern Ireland: N. Carnaghan, Harland & Wolff, Ltd., Engine Works, Belfast.
Nottingham: C. N. T. Manfull, Chellaston House, Thurgarton Street, Nottingham.
Preston: R. G. Ryder, Thos. Ryder & Son, Ltd., Turner Bridge Works, Bolton, Lancs.
Sheffield: J. P. Clare, St. James' Chambers, 38, Church Street, Sheffield, 1.
Shrewsbury Sub-Section: N. E. Allender, The Walker Technical College, Oaken Gates, Shropshire.
Southern: S. Coates, 51, Westbury Road, Regent's Park, Shirley, Southampton.
South Wales and Monmouthshire: J. Murphy, John Curran Engineering, Ltd., 16/17, Buildings, Curran Road, Cardiff.
Sydney (New South Wales): J. M. Steer, 260/262, Kent Street, Sydney.
Western: H. D. Glover, 63, Trelawney Road, Bristol, 6.
Wolverhampton: A. J. Burns, Dudley & Staffordshire Technical College, Dudley.
Yorkshire: Harry Teasdale, John Lund, Ltd., Cross Hills, nr. Keighley, Yorks.

Graduate Section Honorary Secretaries

Birmingham: J. D. Berry, "Ava," Sandy Road, Norton, Stourbridge.
Coventry: E. B. Wall, 82, Keresley Road, Coventry.
London: H. G. Shakeshaft, 37, Blandford Waye, Hayes, Middlesex (Acting).
Yorkshire: J. W. Poole, "Tree Tops," Kings Grove, Villa Road, Bingley.
Wolverhampton: G. W. Clamp, 16, Wells Avenue, Darlaston.
Manchester: H. Bradshaw, 19, Arlington Street, Ashton-under-Lyne.
North Eastern: G. Pool, 16, Kew Gardens, Monkseaton, Northumberland.

Student Centre Honorary Secretary

Loughborough College: T. D. Walshaw, B.Sc., Loughborough College, Loughborough, Leics.

INSTITUTION NOTES

March, 1946

March Meetings.

4th Coventry Graduate Section. A meeting will be held at the Technical College, Coventry (Room A5), at 6-45 p.m., when "Short Papers" will be read.

4th Yorkshire Section. A lecture will be given at the Hotel Metropole, Leeds, at 7-00 p.m., on "Incentives in Industry." Speakers: Messrs. J. E. Hill, B. McMahon and L. J. Serjeant.

9th Yorkshire Graduate Section. Visit to The Kirkstall Electric Power Station, nr. Leeds, at 2-30 p.m.

12th North-Eastern Graduate Section. A lecture will be given by H. W. Kirkby, Esq., of the Firth-Brown Laboratories, on "War Development of Alloy Steels," at the Newcastle and Gateshead Gas Co.'s Demonstration Theatre, St. John Street, Newcastle-on-Tyne, at 6-30 p.m.

12th Luton and District Section. A lecture will be given by Mr. Parr on "The Future of Television," at The Small Assembly Room, Town Hall, Luton, at 7-00 p.m.

12th. Birmingham Graduate Section. A lecture will be given by Dr. J. W. Rodgers on "Quality Control in the Engineering Shop," at the James Watt Memorial Institute, at 7-15 p.m.

13th Wolverhampton Section. A lecture will be given by H. A. Drane, Esq., on "Machine Tools," at the Wisemore School, Walsall, at 6-30 p.m.

13th Preston Section. A lecture will be given by J. E. Southcombe, M.Sc.Inst.Pet., on "Recent Developments in Lubrication," at the Municipal Technical College, Manchester Road, Bolton, at 7-15 p.m.

14th South Wales and Monmouthshire Section. A lecture will be given by Mr. I. S. Morton, B.Sc., A.M.I.Mech.E., Chief Assistant to Dr. D. F. Galloway, on "Drilling Research," at the South Wales Institute of Engineers, Park Place, Cardiff, at 6-30 p.m.

March Meetings—*Cont.*

14th Manchester Graduate Section. Annual General Meeting followed by a lecture on "Gear Cutting," by A. S. Rowley, B.Sc., M.I.Mech.E., at the College of Technology, Manchester.

14th London Section. A lecture will be given by A. E. McRae-Smith, M.A., on "Modern Cast Irons," at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, at 6-30 p.m.

14th Leicester and District Section. A lecture will be given by Mr. Vincent Everard, M.I.Mech.E., on "Industrial Relations," at the Leicester College of Technology, at 7-00 p.m.

15th Birmingham Section. Annual Dinner Dance at the Botanical Gardens, Edgbaston.

15th Coventry Section. A lecture will be given by F. T. Dean, A.M.I.Mech.E., on "Conveyor Systems in Production Engineering," at Coventry Technical College (Room A5), at 6-45 p.m.

15th Western Section. A lecture will be given by T. H. Leitch, A.M.I.P.E., on "Die Construction for Plastic Moulding," at the Grand Hotel, Broad Street, Bristol, 1, at 6-45 p.m.

16th Manchester Graduate Section. Visit to Barlow & Chidlaw, Ltd., Salford.

18th Derby Sub-Section. A lecture will be given by E. W. Hancock, M.B.E., M.I.P.E., on "Time Factor in Industry," at the School of Art, Green Lane, Derby, at 6-30 p.m.

18th Halifax Section. A lecture will be given by S. A. Woodo, Esq., on "Colour Schemes for Factory and Machines," at the Technical College, Huddersfield, at 7-00 p.m.

19th Wolverhampton Graduate Section. Visit to Goodyear Tyre & Rubber Co., Ltd., Wolverhampton, at 2-30 p.m. Annual General Meeting to be held afterwards at the Wolverhampton Technical College, followed by a paper to be presented by Dr. Chapman.

20th Birmingham Section. A lecture will be given by W. W. Taylor, Esq., on "Modern Milling Practice," at the James Watt Memorial Institute, at 7-00 p.m.

20th Manchester Section. Annual Meeting, followed by a lecture on "Cold Heading and Thread Rolling," by T. C. Parker, Esq., at the College of Technology, Manchester, at 7-15 p.m.

March Meetings—*Cont.*

20th Sheffield Section. A lecture will be given by H. Burden, M.I.P.E., on " Developments in Tungsten Carbides," at the Royal Victoria Station Hotel, Sheffield, at 6-30 p.m.

21st Glasgow Section. A lecture will be given by M. B. Hamilton A.M.I.Mech.E., on " Design for Welding, with particular reference to High Pressure Vessels," at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, at 7-15 p.m.

28th Cornish Section. A lecture will be given by Dr. D. F. Galloway, Wh.Sc., A.M.I.Mech.E., A.M.I.E.E., B.Sc.(Hons.), on " Production Engineering Research," in the Lecture Hall, Camborne School of Mines, at 7-15 p.m.

29th Lincoln Sub-Section. A lecture will be given by R. E. Reason, A.R.C.S., on "Super Finish and Its Measurement," at the Lincoln Technical College, at 6-30 p.m.

29th Manchester Section. A lecture will be given by Messrs. J. S. Jones and P. M. Walker, on " Electrodeposited and Allied Finishes," at the Mechanics Institute, Crewe, at 7-15 p.m.

29th North-Eastern Section. A lecture will be given by J. M. Gray, Esq., on " The Production of Pneumatic Tools," at the Newcastle and Gateshead Gas Co.'s Demonstration Theatre, St. John Street, Newcastle-on-Tyne, at 6-30 p.m.

30th Nottingham Section. A lecture will be given by H. Martin, Esq., on " Latest Developments in Welding Technique," at the Demonstration Theatre, Corporation Gas Showrooms, Lower Parliament Street, Nottingham, at 2-30 p.m.

30th Manchester Section. A lecture will be given by Messrs. J. S. Jones and P. M. Walker, on " Electrodeposited and Allied Finishes," at Liverpool University, Brownlow Hill, Liverpool, at 2-30 p.m.

April Meetings.

1st Yorkshire Section. A lecture will be given by Dr. D. F. Galloway, Wh.Sc., A.M.I.Mech.E., A.M.I.E.E., B.Sc.(Hons.), on " Surface Finish in Practice," at the Hotel Metropole, Leeds, at 7-00 p.m.

April Meetings—*Cont.*

4th Leicester and District Section. The Annual General Meeting will be held at the Leicester College of Technology, Leicester, at 6.30 p.m., followed by a lecture, "Some Peace-time Applications of Aluminium Alloys," by E. G. West, Ph.D., B.Sc., and a sound film, "Fabrication of Aluminium."

6th Yorkshire Graduate Section. A "Brains Trust" Meeting will be held at the Great Northern Hotel, Leeds, at 2-30 p.m.

9th Luton and District Section. A lecture will be given by Dr. C. J. Dadswell and Mr. Muirhead on "Drop Stamping," in the Small Assembly Room, Town Hall, Luton, at 7-00 p.m.

13th Manchester Section. A Dance will be held at the College of Technology, Manchester. Full details to follow.

17th Manchester Section. A lecture will be given by Mr. T. Norton, A.M.I.Mech.E., and Mr. Crook, on "Production of Heavy Aircraft," at the College of Technology, Manchester, at 7-15 p.m.

17th Sheffield Section. A lecture will be given by J. E. Sears, Esq., O.B.E., M.I.M,E., on "Measuring Methods," at The Royal Victoria Station Hotel, Sheffield, at 6-30 p.m.

19th Western Section. Film Show—details to follow.

20th North-Eastern Graduate Section. General Meeting and Work's Visit to Messrs. Bren Mfg. Co., Ltd., Team Valley Trading Estate, Gateshead.

22nd Derby Sub-Section. A lecture will be given by Mr. H. Pearson, B.A.Oxon, on "Jet Propulsion," at the School of Art, Green Lane, Derby, at 6-30 p.m.

25th Cornish Section. A lecture will be given by H. Kench, Esq., A.M.I.P.E., on "Discussion on Post-war Problems for the Engineer," in the Lecture Hall, Camborne School of Mines, at 7-15 p.m.

26th Lincoln Sub-Section. A lecture will be given by Mr. F. J. Everest, M.Sc., A.M.I.Mech.E., A.M.I.E.E., A.I.Mar.E., on "Gear Cutting," at Lincoln Technical College, Lincoln, at 6-30 p.m.

27th Manchester Section. Visit to Messrs. A. V. Roe, Ltd., Chadderton.

April Meetings –*Cont.*

27th Nottingham Section. A lecture will be given by H. W. Greenwood, Esq., on "Powder Metallurgy," in the Demonstration Theatre, Corporation Gas Showrooms, Lower Parliament Street, Nottingham, at 2-30 p.m.

27th North-Eastern Section. General Meeting and Works Visit.

27th Yorkshire Graduate Section. Visit to the Operating Equipment of a large Cinema, at 2-30 p.m.

March Committee Meetings.

12th Education Committee, at 10-30 a.m., at the Queen's Hotel, Birmingham.

12th Membership Committee, at 12-30 p.m., at the Queen's Hotel, Birmingham.

— Research Committee, at 11-45 a.m., at Loughborough College, Loughborough, Leics.

15th Finance and General Purposes Committee, at 2-30 p.m., in the TEMPORARY Committee Room, 36, Portman Square, London, W.1.

Technical and Publications Committee meet every Wednesday at 5-30 p.m. in the TEMPORARY Committee Room, 36, Portman Square, London, W.1.

Until further notice, meetings of the Finance and General Purposes Committee, the Technical and Publications Committee, and the London Section Committee will be held in the TEMPORARY Committee Room at 36, Portman Square, London, W.1. All correspondence is still to be addressed to No. 10, Seymour Street, London, W.1.

Council Meeting.

The next meeting of the Council will be held on Friday, 22nd March, 1946, at 11-00 a.m., at the Institution of Civil Engineers, Great George Street, London, S.W.1.

Coventry Section.

The Coventry Section has organised a full-scale conference on welding processes and equipment, to be held at the Rugby Works of the B.T.H. Co. Ltd., on April 6th, 1946, and desires to invite members of all grades of the Institution to attend.

Mr. B. Newbold, President of the Coventry Section, will convene the meeting, and will be supported by Sir Norman V. Kipping, J.P., Director-General of the Federation of British Industries, the Rt. Hon. Lord Sempill, A.F.C., and Mr. J. E. Blackshaw, Chairman of Council.

A brief outline of the programme is given below. It will consist of six lectures and discussions in two parallel groups of three, together with a series of demonstrations, all showing the latest technique and methods in the many branches of the subject.

9-30 a.m.	Conference convened.	
	Group "A" Lectures.	Group "B" Lectures.
10.00 a.m.	Arc Welding. Lecturer: Mr. F. L. Swan.	Resistance Welding. Lecturer: Mr. F. W. Ayers.
11.15 a.m.	Flash Butt Welding. Lecturer: Mr. W. H. Millwood, A.M.I.Mech.E. (vice Mr. J. M. Sinclair.)	Gas Welding. Lecturer: Mr. F. Clark, M.B.E.
12.30 p.m.	Lunch.	
2.00 p.m.	Continuous demonstrations on selected and requested subjects in separate demonstration building, by the six participating firms.	
3.45 p.m.	Resistance Welding Lecturer: Not yet nominated.	Arc Welding. Lecturer: Dr. E. C. Rollason, M.Sc.
5.00 p.m.	Tea and official conclusion of conference.	
5.30 - 7.00 p.m.	Overspill demonstrations and Film Show for those members who can remain.	

Admission tickets are strictly limited owing to catering difficulties, and personal application, with full particulars of name, business, address and grade in the Institution should be made to the Conference Secretary, Mr. B. G. L. Jackman, A.M.I.P.E. at 51, Common Lane, Kenilworth, Warwickshire, not later than March 16th.

At the present time, it would seem unlikely that visitors can be admitted, but if applications from non-members are received they will be filed and dealt with in rotation, should there be any tickets available.

Honours

Our congratulations are extended to Sir Norman V. Kipping, J.P., M.I.P.E., M.I.E.E., on the Knighthood recently conferred on him by His Majesty the King, and to Mr. R. W. Poyser, A.M.I.P.E., and Mr. D. F. Horne, A.M.I.P.E., who have both been awarded the M.B.E.

A prominent member of the Institution, Sir Norman was President of the London Section during 1938/40, and Chairman of Council for the year 1941/42. Born in 1901, he was educated at London University College School. Between 1922 and 1942, he held various positions in Standard Telephones & Cables, Ltd., finally becoming Works Manager, designing and managing the new Southgate factory of 10,000 employees.

In 1942, Sir Norman was appointed Head of the Regional Division of the Ministry of Production, and in 1945, became Under-Secretary to the Board of Trade. In January of this year, he took up his present appointment as Director-General of the Federation of British Industries.

Mr. Poyser joined the British Aeroplane Company in 1927 as a jig and tool draughtsman, and is now works engineer, Engine Division.

Mr. Horne is Group Production Engineer and Chief Planning Engineer for Messrs. Helliwells, Ltd., Stratford-on-Avon.

Personal.

Mr. W. Barnes, A.M.I.P.E., has been appointed Southampton and Southern Counties Representative for David Brown and Sons, Ltd., Huddersfield.

Obituary.

We deeply regret to record the death of Mr. A. J. Shelley, M.I.P.E. A recognised authority on Press Tools, he had spent 26 years with the Austin Motor Co., Ltd., as Tool Superintendent and Press Shop Manager. For three years previous to his death, he was Works Manager at Drummond Bros., Guildford.

Books Received.

Fine Boring With Diamond Tools. Published by the Ministry of Supply. (Stationery Office, 4d. net.)

Issue of Journal to New Members.

Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

Important.

In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

" Atomic Energy."

It is regretted that on Page 54 of the February Journal, at the end of Mr. Pearson's paper on " Atomic Energy," the first line, which reads "..... apart to be safe. As the size of the bomb increases the two sections ....," was inadvertently transposed, and should appear at the bottom of the page.

Mr. Pearson's statement will then read: " If you make the bomb about the smallest size possible, though still big enough to explode, you need keep the two halves only the smallest distance apart to be safe. As the size of the bomb increases, the two sections have to be kept further away, it is just a question of size."

DIFFICULTIES AND DEVELOPMENTS IN DEEP DRAWING AND PRESSING

By J. D. JEVONS, Ph.D., B.Sc., F.R.I.C., F.I.M.

A meeting of the London Section of the Institution was held at the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, on Thursday, January 17th, 1946, at 6.30 p.m.

The CHAIRMAN said that Dr. J. D. Jevons, the author of the paper about to be read, needed no introduction. He was an authority of renown in the sphere of metallurgy, particularly with regard to press work. There was a lack of literature on that subject, but such as there was had been contributed very largely by Dr. Jevons.

The following paper was then read on Dr. Jevons' behalf by Mr. E. S. Lloyd.

(*Author's Note.—Owing to the impossibility of reproducing all the* 93 *illustrations shown as lantern slides, this printed paper is a somewhat abridged version of the original one read before the London Branch of the Society on* 17*th January*, 1946.)

MR. CHAIRMAN, LADIES AND GENTLEMEN,

I had some difficulty in deciding how to approach the subject of "Deep Drawing and Pressing" upon which I have been asked to talk to you this evening. If I had attempted anything approaching a general survey of the deep drawing and pressing process with its specialised applications and its virtually inseparable ancillary processes, I could have made only a very short reference to each of these, and this would have meant dealing with most of them in a rather elementary manner. I do not think that this would meet with your approval, because the very fact that you are Production Engineers and that you have come to this paper on deep drawing and pressing suggests that you will be familiar with the elementary principles of this subject and, hence, that you will expect at least a moderately advanced treatment of this fascinating process.

I propose, therefore, to deal with a limited number of matters which I have found are not always understood as well as they might be, or in which recent interesting developments have occurred.

Quality of Sheet Purchased.

First, a few comments seem desirable regarding the quality of the sheet purchased for deep drawing and pressing, because it does not always appear to be realised that good pressings cannot be made from sheet of poor quality. Unsatisfactory sheet may give rise to

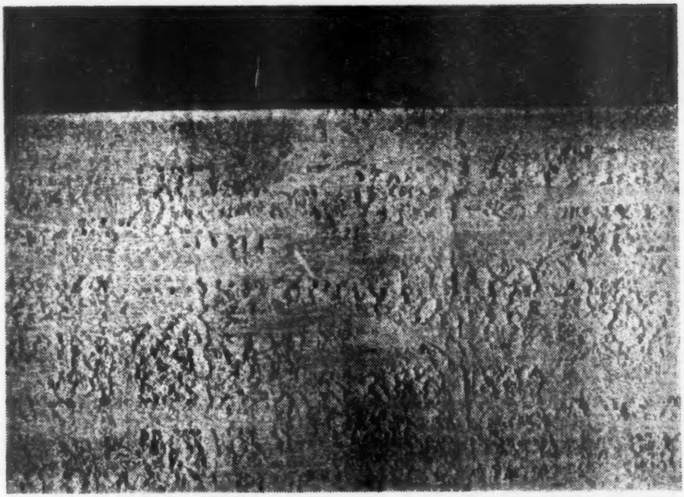
two distinct kinds of trouble: it may cause a considerable proportion of pressings to fail under the press, or it may exhibit various kinds of local blemishes, or perhaps an undesirably rough surface on the finished pressing, which will spoil its appearance and, if the article has to be plated, will produce blisters and other plating defects.

Common causes of actual breakage of sheet in the tools are: non-metallic inclusions or internal discontinuities; too low ductility engendered by too small a crystal size or too much cold-rolling after the final anneal; and, sometimes, various metallurgical defective conditions, often peculiar to different metals, which we cannot discuss tonight.

In brass and copper, casting defects on the surface of the ingot produce what are called "spills" in the sheet rolled from it. These are sub-surface discontinuities which, when small, may merely produce blisters and jagged streaks on the surface of pressings or, when severe, may cause the sheet actually to fracture under the press. Spills do not occur in steel, but, in ferrous sheet, considerable trouble is often caused by streaks or planes of slag. Sometimes these lie near the surface, and produce a blemish which can be very like a large spill in non-ferrous sheet. More often the slag inclusions occur near the middle of the sheet and, when severe, they may cause the sheet to break with what is called a "laminated" fracture. Occasionally the internal "lamination" is so complete and so extensive that a specimen cut from the sheet can be peeled into two as if one were pulling apart two slightly adhesive cards.

Too large a crystal size will produce a rough surface when sheet is pressed. Sometimes this is of no great detriment; but, when the article has to be polished, a rough surface may increase polishing costs several hundred per cent. Even when such a surface has been polished, plating defects may arise through the mountain crests of the rough surface having been smeared over the valleys, leaving an unsound surface into the crevices of which pickling and plating solutions find their way to ooze out later.

I venture to suggest to you, as Production Engineers, that in many instances the purchase of low-priced sheet for deep pressing is false economy. If costs were worked out carefully, it would often be found that even a quite substantial *increase* in the price paid for sheet would bring about an actual *reduction* in the total cost of producing a given article owing to the virtual elimination of rejects, to the greater ease of processing, particularly when any polishing has to be done, and to the smoother and more rapid flow of work through the factory. Accurate figures are hard to obtain, but I can quote one striking instance where an increase of no less than 80 per cent. in the purchase price of sheet, accompanied by an increase of 20 per cent. in expenditure on tool maintenance, enabled



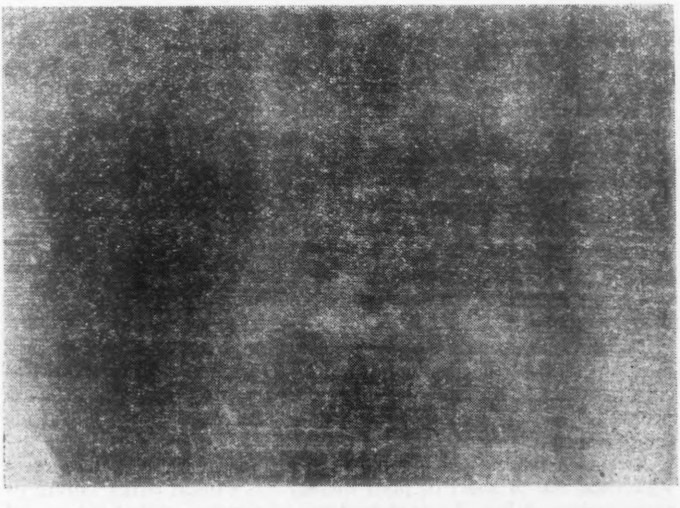


FIG. 1. Surface of (*top*) black and (*below*) bright cold-rolled low-carbon steel strip for deep pressing.

rough polishing to be eliminated entirely, buffing costs to be reduced by 30 per cent., and a saving shown in the total cost of production of a certain steel pressing. Observe that an increase of no less than 80 per cent. in the cost of the sheet was more than recovered in the resulting reduction in production costs ; yet often those responsible for the choice and purchase of sheet hold up their hands in horror if an increase of only 20 per cent. or even 10 per cent. is suggested as a means for decreasing the percentage of scrap produced and for generally facilitating production. In the absence of actual figures, it is, unfortunately, a very difficult task to convince some people that the saving they imagine they are making by buying cheap grades of sheet is, in fact, entirely illusory.

To emphasise this very important matter may I illustrate my contention with a few more slides. The top picture in Fig. 1 shows the surface of a piece of poor quality "black" sheet which has been rubbed lightly with emery cloth to render the various surfaces blemishes more easily seen in a photograph. "Black," by the way, is the adjective used to describe steel sheet which still carries the coating of oxide formed when annealing is carried out without the help of a protective atmosphere. Black sheet is, of course, cheap ; but the oxide can conceal a multitude of surface defects which will still be present, perhaps in an intensified condition, after pressing. When, as in this instance, the defects are pronounced, they may cause a considerable percentage of pressings to fail in the tools. Contrast the appearance of this surface with that of a good, deep-pressing quality steel sheet such as that shown, at the same magnification, in the lower picture of Fig. 1. Bright-finished sheet is, naturally, more expensive ; but, as I have tried to show, the supposed saving in cost resulting from the use of low-priced sheet is often illusory.

Black sheet has another serious disadvantage in that the oxide which it bears rapidly scores the surface of the tools in which it is deep-pressed. Greatly increased friction, caused partly by the impossibility of maintaining a continuous film of lubricant under such conditions and partly by the dragging action which the rough surface of the die exerts on the sheet sliding over it under high pressure, is then unavoidable.

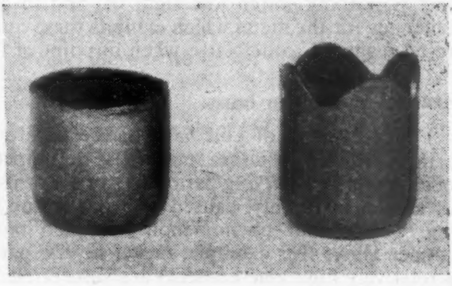
The internal structure of a sheet is as important, indeed perhaps more important, that the condition of its surface ; but any detailed consideration of the influence of microstructure upon deep-drawing properties is an essentially metallurgical subject and, hence, outside the province of this paper.

As the instances which I have chosen so far have been ones in which the use of sheet of poor quality has caused either failure or some serious defect, I ought perhaps to emphasise that the use of good quality—and hence more expensive—sheet will often reduce the

total cost of production even in instances where the use of inferior sheet does not actually result in the making of a high percentage of rejects. This is particularly true when one, as distinct from several, interstage annealings have to be used to enable the desired depth of draw to be carried out. Annealing costs money, prevents a smooth flow of work through a line of presses and, unhappily, introduces the possibility of scrapped work owing to the annealing treatment not being done correctly, or perhaps to the sometimes unavoidable incidence of critical strain crystal growth. Furthermore, it entails either the use of very expensive "clean-annealing" furnaces utilising a protective atmosphere, or else subsequent pickling, which is still another, and often an unpleasant, operation. From every aspect it is, therefore, advantageous to avoid interstage annealing whenever possible, and this desirable end can sometimes be achieved by substituting first-class deep-drawing quality sheet for material of mediocre quality. A certain thin-walled steel container approximately 4½ inches deep and 1 inch diameter illustrates this point rather well. The combined use of the very best quality sheet, well-maintained tools and a good lubricant enabled this container to be deep-drawn to its full depth without the help of interstage annealing, thereby facilitating its production very greatly. When sheet of slightly inferior quality was used, at least one interstage anneal was found to be essential.

A word about "ears," the name given to a wave-like formation often seen on the periphery of cups deep-drawn from sheet having pronounced directional properties, as I have found that the belief still persists in some quarters that "earing" is caused by incorrect tool design or setting. Fig. 2, which shows an early stage in the deep-drawing of a bullet envelope from cupro-nickel alloy sheet, proves that this belief is incorrect. It will be seen that the cup on the left has practically no "ears," whereas the one on the right exhibits very pronounced "earing." These two cups were drawn in the same tools with the same lubricant and without any alteration in setting

FIG. 2. Cups for bullet envelopes, deep-drawn in the same tools and under exactly similar conditions from two different batches of cupro-nickel sheet, proving that the "ears" on the periphery of the right-hand cup were caused by "directional" properties in one lot of sheet and not by conditions of drawing.



or procedure whatever, the only difference being that the blanks came from different batches of sheet. In one, directional properties were small ; in the other, a difference in the rolling and annealing procedure used in the rolling mill has produced very marked directional properties. I think you will agree that this example demonstrates beyond all doubt that "earing" is caused by "directional" properties in the sheet itself, not by tool setting.

Defects in, and pecularities of, the metal.

Having considered the quality of the sheet metal used, we will pass into the press shop to study some of the happenings and processes which we shall find there. A blank, or, sometimes, strip is placed under the tools, the operator sets the machine in motion, the guard shoots across to knock a careless operator's hand out of the way and —wallop !—down comes the punch. If everything goes according to plan, out comes a finished pressing, or perhaps only a partial pressing, all in one piece and with a smooth surface, free from roughness, scores or localised blemishes. If things do *not* go according to plan, a torn, split, or, sometimes, curiously fractured pressing may come out which, although interesting as a metallurgical exhibit, has little commercial value, and hence is not welcomed by directors nor even by those lesser lights who are responsible for maintaining production output.

Several whole papers could be devoted to a study of the causes of unfortunate happenings of this kind : hence, following the aim of this particular paper, I propose to restrict my remarks to four causes of trouble which seem to be understood less well than most. These are season-cracking in brass, strain-age-embrittlement and stretcher-strain markings in steel, and critical strain crystal growth. It is incorrect to describe these as defects because, although they cause trouble and lead to the production of defective pressings, they are the manifestation of natural, if unwelcome, properties of brass and steel, and are not caused by any unusual or defective condition. This fact is, I think, often lost sight of, and in consequence there is a tendency for the metal which exhibits these quite natural phenomena to be regarded as defective when in point of fact it is not so.

Season cracking in brass.

I expect many of you have had your attention drawn to brass articles which have either split or else developed a network formation of cracks after a varying period of storage or use. This kind of failure is, almost invariably, caused by what is known as "season-cracking," a peculiar phenomenon to which brass and certain other copper alloys (for example, nickel-silvers, particularly those having a relatively high zinc content) are susceptible.

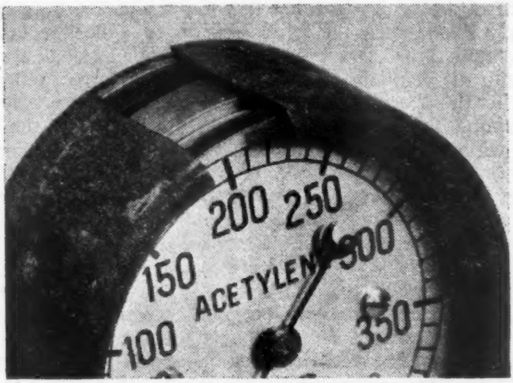


FIG. 3. Season-cracking in deep-drawn brass pressure gauge cover. A piece of the wall has fallen out completely.

Fig. 3 shows a typical failure, of the splitting type, where a piece of the side of a deep-drawn brass cover off a pressure gauge has fallen out completely. Both this and the other type of failure, that is the development of a network formation of cracks, are, unhappily, seen all too often in deep-drawn or pressed brass articles.

Although the precise mechanism by which season-cracking occurs is not understood fully, it is known to be caused by the action of minute traces of ammonia (and perhaps other substances, for example, certain amines) present in the air, although quite recently it has been shown that both moisture and free oxygen must also be present. Metallographic examination shows that in alpha brasses season-cracks are always intercrystalline. The presence of common salt sometimes produces cracking, but it is not yet established whether this is true season cracking merely aggravated by the influence of salt, or whether it is a distinct form of stress-corrosion-cracking not dependent, as is true season-cracking, upon the presence of ammonia. Be this as it may, there is no doubt that the tendency for stressed brass to crack is greater than usual in the vicinity of salt mines and at the seaside.

Season-cracking can usually be prevented by giving all cold-worked brass parts a low-temperature stress-relieving anneal at a temperature of 300 to 320°C. for from half to three-quarters of an hour. This treatment is simple, and its need now known fairly widely ; hence it is surprising that it is still often omitted from production schedules. Unless it is given to all deep-drawn or pressed brass parts, the possibility of failure by season-cracking must always exist.

A word of warning regarding this low-temperature annealing is necessary. Even when the wise decision to anneal is taken and enforced regularly, it sometimes happens that pressings are merely packed into the chamber of a muffle set at the correct temperature and left for the specified time. This procedure will nearly always lead to trouble because, under these condition, some of the work in the oven will never reach the necessary temperature, and some may reach it only for a short time before the charge is withdrawn. Except in special instances it should be an axiom that the stress-relieving anneal should *always* be carried out in furnaces equipped with fans to circulate the air in the furnace chamber. There are two methods of doing this. In one, fans are fitted to the roof of an otherwise ordinary furnace. This is quite satisfactory if the charge is of such a nature that relatively slow-moving air can circulate freely, and if adequate time is allowed for the charge to heat up before the start of the actual annealing period is deemed to have begun. In the other method what are called " forced circulation " air furnaces are used. In these there is an inner chamber, surrounded by a baffle, to contain the work, and an outer fairly narrow annular space containing the heating elements. A fan in the base of the furnace circulates air at a high velocity past the heating elements and through the work. These furnaces give very rapid and uniform heating even to a charge of small, closely packed articles.

Strain-age-embrittlement.

This is the name given to a troublesome, and often dangerous, phenomenon which renders cold-worked low-carbon steel liable to crack spontaneously either shortly after working or, perhaps, some time afterwards during service. Although all kinds of low-carbon steel show strain-age-hardening tendencies after cold working, it is only in steel which has been manufactured by the basic Bessemer process in which, so far as my experience goes, the loss in ductility becomes so great that spontaneous cracking is likely to occur. Fig. 4 shows what happened to some deep-drawn cups, which normally gave no trouble, when a consignment of basic Bessemer steel found its way, unannounced, into the press shop.

It is important to remember that hardness tests give no indication of the incidence of strain-age-embrittlement. Thus two kinds of steel which have been cold-worked and allowed to stand might show approximately the same small increase in hardness and tensile strength ; but, whereas one might have lost only a small proportion of its ductility, the other might have become so brittle that slight deformation, or even merely standing, will cause it to crack.

Certain conditions of temperature have a marked influence upon

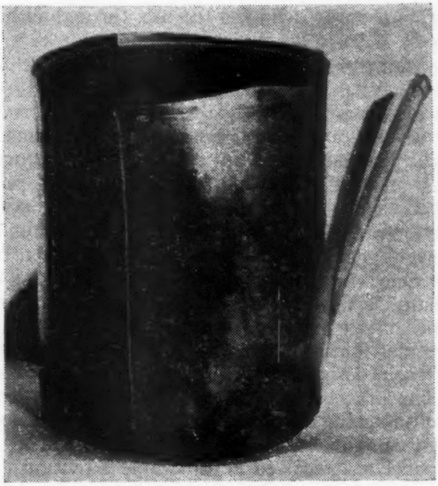


FIG. 4. Splitting in a cup deep-drawn from low-carbon steel made by the basic Bessemer process.

strain-age-embrittlement. Low temperatures increase the tendency to crack very considerably, but the effect is only *transient* and, when the temperature is restored to normal, no permanent change in embrittlement can be detected. This behaviour sometimes causes trouble in press shops during unusually cold weather, or when a bin of pressings waiting to be annealed is pushed out of doors for a night during a frost. Exposure to a slightly elevated temperature, say from 200 to 350°C. produces a marked *permanent* increase in embrittlement, 250°C. being the most dangerous temperature of all. Heating cold-worked steel to 250°C. for half an hour has, indeed, become the recognised treatment for inducing the maximum degree of embrittlement in any steel when it is desired to do this for experimental purposes. The important thing to notice is that this temperature range (200 to 350°C.) covers the stoving temperatures given to most stoving and hard-drying paints and enamels. Hence care should be taken to ensure that pressings which have to be given a stoved finish are not made from basic Bessemer steel. The failure of relatively unimportant unstressed components is merely annoying ; but, in the instance of stressed parts, failure may have serious consequences. A certain stove-enamelled pressed steel cross member from a well-known truck cracked in considerable

numbers during the war owing to the use, through either ignorance or carelessness, of basic Bessemer steel.

This particular form of strain-age-embrittlement is commonly termed " blue brittleness " owing to the fact that the temperature range which induces maximum embrittlement also produces a blue oxide temper-colour on steel. There is evidence to suggest that steel having a high phosphorus content is unusually susceptible to blue-brittleness. Hence a watch should be kept on the proportion of this element as well as on the method by which the steel has been made.

Unlike season-cracking in brass there is, unhappily, no simple remedy for strain-age-embrittlement. It can, however, be prevented in two ways. One is by annealing cold-worked parts at a temperature of not less than 550°C. This treatment is often unwelcome, or even impossible, because it produces appreciable softening, an alteration which may render thin-walled pressings unacceptable when it is the intension of their designer to use them in the fully cold-worked condition. The other way is to purchase a special kind of steel, known as " non-ageing " steel, which, as its name implies, is free, or practically free, from strain-age-hardening tendencies. Although this kind of steel has received considerable attention in American technical literature, as far as I can ascertain it is not yet used on an industrial scale in trans-Atlantic press shops. In this country, I believe it is correct to say that, up to the present, only experimental casts, mostly on a laboratory scale, have been made.

Although the precise mechanism of strain-age-hardening is not yet understood fully, it is known that this happening can be reduced to negligible proportions in two distinct ways : one by removing the carbon in the steel completely, and the other by what may be described as fixing all the carbon in a staple form, for example in the form of certain carbides which hold it during cold-working and annealing operations and thus prevent it from playing mischievous tricks. The first method, that is the complete removal of carbon, has been employed successfully in America on at least a semi-production scale by annealing finished sheet or strip in an atmosphere of damp hydrogen at a temperature of about 750°C. The second method, that is " fixing " the carbon in a harmless form by means of additions made to the molten steel in the ingot mould, is easier and less expensive. The usual method is to add more than enough titanium to combine with all the carbon present, the result being that tiny globules of complex titanium carbides are formed which hold the carbon, present normally as simple iron carbide, and prevent it from going into solution.

In this brief review of the phenomenon of strain-age-hardening I have confined my remarks mainly to the particularly virulent and dangerous form known as strain-age-*embrittlement*. There is, however, a milder form, which in the opinion of some authorities

is attributable, at least in part, to rather different causes. The principle effect of this milder form is to make sheet which has been lightly cold-rolled to prevent stretcher-strain markings forming when it is pressed gradually revert to its original susceptibility to this phenomenon. At the same time, a peculiar kink at the yield point in the stress-strain curve, which is eliminated by cold-rolling, gradually returns. This brings us to stretcher-strain markings; but, before doing this, I want to make a brief reference to what is called "stress cracking." This term is often used somewhat loosely to describe any kind of splitting which occurs in deep-drawn parts either during or after drawing. With four exceptions which I will describe, splitting is, in my experience, always the result of season-cracking in non-ferrous metals and strain-age-hardening in steel. The exceptions are: austenitic steel, which when severely cold-worked will often split, as shown in Fig. 5, unless annealed within half an hour of being worked; metal of any kind which has been deep-drawn or otherwise cold-worked to such an extreme extent that it has reached the point of rupture; heavily cold-worked steel of thin section plunged into a molten-bath of tin or

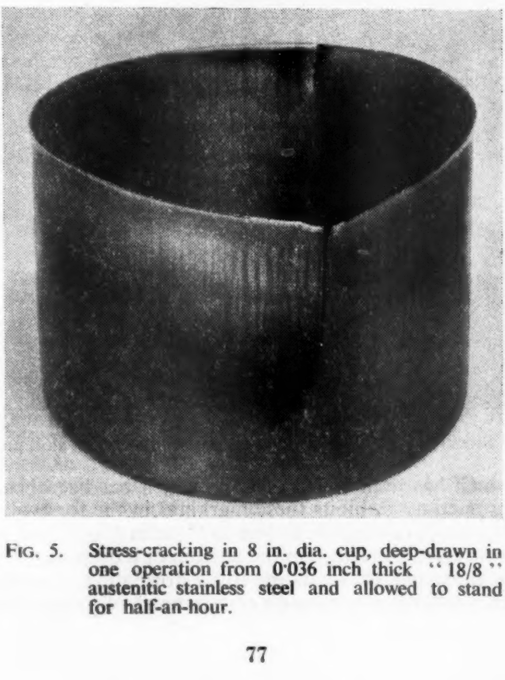


FIG. 5. Stress-cracking in 8 in. dia. cup, deep-drawn in one operation from 0·036 inch thick "18/8" austenitic stainless steel and allowed to stand for half-an-hour.

zinc and, a trouble seldom encountered in these days, heavily cold-worked brass of high iron content suddenly thrust into an annealing furnace. Except in these special instances it is, therefore, wrong to call splitting " stress cracking."

Stretcher-strain markings.

Annealed low-carbon steel is subject to a peculiar phenomenon known as " stretcher strain markings " ; " strain figures " and " Lüder's Lines " being other names given to the same happening. Although these markings and their method of formation are of intriguing interest academically, and happen to have been a pet hobby of mine for a good many years, they often cause a great deal of trouble industrially, because they are clearly visible on a smooth surface and, as they are sunken, are very costly to polish out. These markings are notoriously difficult to photograph, but Fig. 6 shows with reasonable distinctness typical markings on the flat bottom of a pressed steel tray.

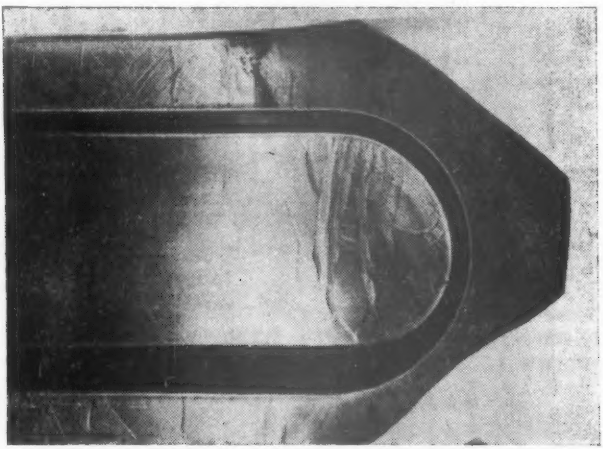


FIG. 6. Stretcher-strain markings on a shallow low-carbon steel pressing.

Strip which has been coiled or sheet which has been bent during handling sometimes exhibits these markings in the form of more or less parallel bands commonly known as " flutes " or " coil breaks." Fig. 7 shows these markings on the bottom of a deep-drawn cup and illustrates the need for avoiding their formation, because, once formed, they will often remain on certain areas of finished pressings.

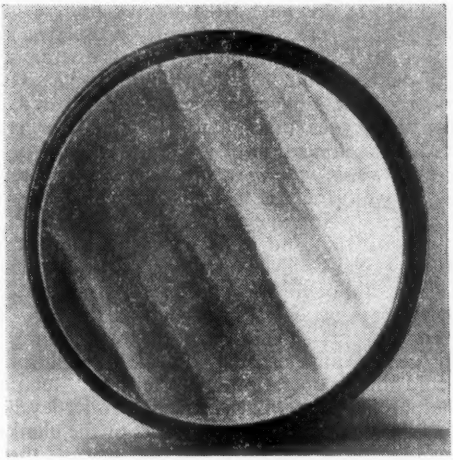


FIG. 7. "Flutes" or "coil breaks" on the bottom of a deep-drawn low-carbon steel cup.

A description and a discussion of the many theories which have been advanced to explain this peculiar behaviour of low-carbon steel would need a paper to itself. Briefly, however, it can be said that stretcher strain markings are the surface manifestation of curious wedge-shaped blocks in the metal beneath, which appear at the upper yield point of annealed low-carbon steel. This particular metal is peculiar in that its stress-strain curve exhibits a well-defined drop at the yield point which, in fully softened steel, may extend a substantial distance to the right in a roughly horizontal direction. The length of this horizontal part represents what is termed the "yield point elongation," and, the greater this value is, the more pronounced will be the stretcher-strain markings formed under suitable conditions of straining.

Those whose experience of stretcher strain markings is confined to the press shop often ask why these markings, which as we now see are the surface manifestation of solid distortion wedges, hardly ever appear straight and hence do not seem to fit in with the theoretical explanation which I have just outlined. The reason is that, in a pressing, the stress system is rarely one of simple tension, that it is continually changing, and that the wall of the pressing is itself often altering in shape both during and after the formation of the distortion wedges. In spite of this, if a relatively small area of an apparently flamboyant pattern on a pressing is viewed as an isolated

field, the markings in this field often show definite evidence of the true, or unmutilated, angles and symmetry postulated by theory.

Leaving theoretical considerations, the essentially practical significance of the behaviour I have just described is that when steel which exhibits this phenomenon is pressed, those parts of the pressing which have undergone an amount of plastic deformation corresponding to a tensile elongation of less than about 3 or 4 per cent. *will bear stretcher strain markings.* They cannot be prevented, and the only way to avoid them is to use sheet which does not exhibit this phenomenon. "Non-ageing" steel, which we have already discussed, can be used if and when it can be obtained. Secondly, ordinary steel sheet can be given a light cold-working operation of a severity such that, although the subsequent formation of stretcher-strain markings in it is prevented, its capacity to undergo deformation by deep drawing or pressing is curtailed by an almost negligible amount. This can be done either by the sheet supplier by means of a final light cold-rolling operation, often termed "temper-rolling," or else by the purchaser by what is called "roller-levelling." This operation consists of passing either the sheet or the blanks through a series of staggered rolls which flex it first one way and then the other. One important difference between these two methods is that whereas the influence of temper-rolling lasts for a period of some months, the exact length depending on the temperature of the storage room, that of roller-levelling lasts for a matter of hours only. It is, therefore, essential to carry out this operation as shortly as possible before pressing.

A point worth bearing in mind is that it is better to roller-level blanks than the strip from which they are to be cut because, in order to obtain the maximum benefit, it is desirable to pass the metal through the rolls in one direction and then again in a direction at right angles to the first. This point is not known so widely as it might be.

Critical strain crystal growth.

We come next to a source of trouble which, like the other three we have just considered, is, unfortunately, caused by a natural property of certain metals and, for this reason, cannot always be prevented even by the most carefully controlled annealing. This is "critical strain crystal growth," scientifically a most interesting although industrially a most unwelcome phenomenon, which is exhibited by certain metals, for example, aluminium, copper, aluminium bronze and low-carbon steel. When, as a result of cold work, these metals are strained to a certain critical amount and then annealed, crystal growth of an entirely abnormal kind occurs.

This is illustrated rather nicely in Fig. 8, which shows a cross section through a piece of low-carbon steel strip which has been bent

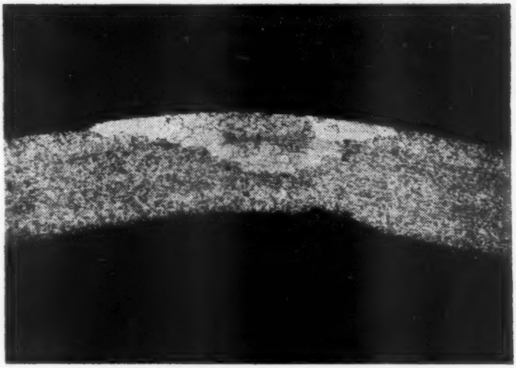


FIG. 8. Etched section through a piece of low-carbon steel strip bent and annealed below the critical temperature, showing occurrence of critical strain crystal growth on the tension side of the bend.

and annealed. You will notice that abnormal crystal growth has occurred only in a small region on the tension side of the bend in which the strain happens to have been within the critical range. When making pressings from metals which are susceptible to critical strain crystal growth the press-man is, obviously, often in a quandary, because it may be difficult, and sometimes impossible, to impose the desired amount of deformation without the help of interstage annealing ; yet, if annealing is given, critical strain crystal growth cannot be avoided in certain regions.

The practical effect of critical strain crystal growth is, naturally, like that of over-annealing, only more so. Fig. 9 illustrates a bad example in a mild steel funnel-shaped pressing, the surface of which, as you can see, is quite abnormally rough. Fortunately, steel is unique in that a remedy for critical strain crystal growth exists. This remedy is to normalize instead of to anneal : that is to heat the pressings above the critical temperature of the steel, which for deep-drawing quality steel is usually about 920°C., for a short time and then to cool relatively rapidly instead, as in annealing, of heating for a longer time at a temperature well below the critical one.

A practical objection which is sometimes raised against the apparently simple remedy of normalizing instead of annealing steel pressings is that the higher temperature greatly intensifies the scale formed on the surface and, hence, the difficulty of subsequent pickling. The remedy is, of course, to normalize in controlled-

FIG. 9. Abnormally rough surface on deep-drawn steel article, caused by an excessively large crystal size produced by critical strain crystal growth.

atmosphere continuous bright-annealing furnaces. Furnaces of this kind are, unfortunately, expensive ; but they overcome so many of the difficulties associated with pickling that they are, in my opinion, a wise investment for any press-shop, particularly when its product has to be plated.

Before leaving critical strain crystal growth I must warn you that this phenomenon is occasionally to be found in low-grade steel sheet as delivered to the user. Under these circumstances its effect may be encountered even though in the production of his pressings the user does not anneal them at all. The remedy is, obviously, to buy good quality sheet or strip from firms of established reputation.

Interstage-annealing.

In this discussion of critical strain crystal growth the word "annealing" has cropped up. Annealing, meaning in this particular instance the interstage annealing of pressings, tends to be regarded as a nuisance to be avoided whenever possible ; and, perhaps, because of this, it does not always receive the same care and thought as press operations. Interstage annealing is, certainly, an operation which, on economic grounds alone, should be used

only when the desired depth of draw cannot be accomplished without it ; but this is no excuse for pushing it into the background as if it were the family skeleton of the press-shop or for neglecting to give to it the care and scientific study accorded to other matters. Hence, although so commonplace a topic as annealing may seem out of place in this review of rather special items, I am going to devote a few minutes to its consideration.

When metal is cold-worked by any process which produces plastic deformation, for example by deep drawing or pressing, it work-hardens. I shall not attempt to go into the theory of work-hardening tonight, because all that really concerns us is the fundamental fact that cold-working reduces the ability of metal to suffer further plastic deformation. In other words, there is a limit to the amount of cold-working which can be inflicted on a metal without causing cracking or rupture, although the actual amount varies considerably with different metals. Pure aluminium, for instance, has a very low rate of work-hardening, and will withstand a really extraordinary amount of cold deformation when manipulated carefully. For example, a 1-inch diameter blank has been deep-drawn in thirteen stages into a $\frac{5}{32}$-inch diameter tube without the help of any interstage annealing whatever to remove the work-hardening caused by cold-drawing. Austenitic stainless steel, on the other hand, has a relatively high rate of work-hardening, and would not undergo anything approaching this amount of deformation unless quite a number of interstage annealings to remove the effects of work-hardening and to restore the ductility of the metal were interposed at various stages in the sequence of drawing operations.

The rate of work-hardening of a metal is reflected rather strikingly in what are known as true stress-strain curves, a number of which are illustrated in Fig. 10. I will not take up time with an explanation of how this form of curve differs from the more conventional form with which you are no doubt familiar, and will merely direct your attention to the important fact that they give an idea of the *relative* rates of work-hardening of some of the metals commonly used in the press shop. Notice that the two metals I have just mentioned, that is austenitic steel and pure aluminium, lie at opposite extremes, and that brass and low carbon steel lie roughly midway between these two extremes.

Leaving theoretical considerations, the practical result of work-hardening which interests you is that the total amount of deformation which has to be inflicted on sheet in order to press or draw it into the desired shape is, in many products of the press-shop, so large that one or more interstage annealing treatments have to be given during the sequence of press operations. Not many years ago it was an axiom among sheet and strip suppliers that 90 per cent. of users would ruin even the best sheet and strip delivered to

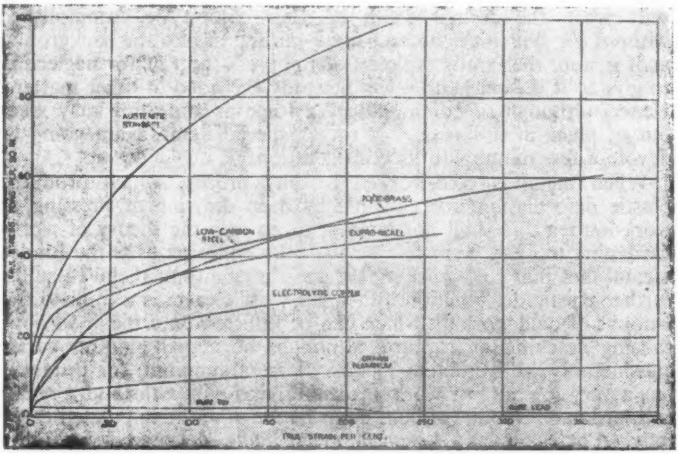


FIG. 10. "True" stress-stain curves, illustrative of the different rates at which various metals work-harden when cold-worked. (*Swift.*)

them if they annealed it. I am sorry to say that, at the time, this axiom was true ; and, even today, unsatisfactory interstage annealing is responsible for a considerable proportion of the failures encountered in the press shop and, also, for the difficulty and high cost of polishing the rough surface which it produces. It is also true that not so many years ago the furnaces then available did not allow annealing temperatures to be controlled accurately ; but, today, there is no excuse whatever for unsatisfactory annealing except, perhaps, that the controlled-atmosphere furnaces and auxiliary equipment needed to give what has come to be known as "bright" annealing are still expensive when compared with the old chambers of horror into which good metal was often thrust for interstage annealing. Although some latitude is, fortunately, usually allowable, certain fairly definite conditions as to time and temperature must always be observed if cold-worked metal is to be annealed properly. Failure to observe these conditions, which are simple and well-known, will invariably lead to trouble in either the press shop, the polishing shop, or the plating shop. Table 1 gives a rough guide to the best annealing temperatures for some of the more common metals handled in the press shop.

Under-annealing will, of course, fail to restore the desired degree of ductility to cold-worked metal ; hence an under-annealed partial-pressing is likely to fail in the press when further deep-pressing is

TABLE I

ANNEALING TEMPERATURES FOR COLD-WORKED METALS

Aluminium	350—390°C.
4—10% Mg-Al alloy	350—390°C.
Duralumin	330—350°C.
(Solution treat.	495±50°C.)
Copper	450—550°C.
70/30 Brass	500—600°C.
Low carbon steel	650—850°C.
(Normalise	900—920°C.)
High carbon steel	650—720°C.
(Normalise	750—800°C.)

attempted. It may seem strange that in these days, when most furnaces are equipped with pyrometers, under-annealing can happen. Unhappily, pyrometers do not render annealings—or, indeed, any other heat-treatment operation—foolproof: commonsense must still be exercised. *The mere fact that a pyrometer fitted to the side, back, or perhaps the roof of a furnace is indicating a certain temperature is, in itself, no guarantee that work in the furnace has attained this temperature.* Adequate time *must* be allowed for the whole of the charge to reach the desired temperature which, it should be noted, may not always be the same temperature as that indicated by the furnace pyrometer if this happens to be fixed in a relatively hot or cool part of a large furnace chamber.

It sometimes happens that a furnace is filled with a number of relatively small partial pressings, and that although the annealing temperature is correct, the time of soaking is insufficient to allow the middle, or inner, part of the charge to reach this temperature. Under these circumstances only a percentage of pressings may fail under the press and, as the pressings will be all mixed up when they are unloaded from the furnace, the cause of this may seem mysterious to those who do not know what to look for or have not the facilities for proper metallurgical examination.

Over-annealing is more common and, as a rule, is easily detected by mere visual examination because subsequent pressing operations will produce a rough surface. The upper picture in Fig. 11 shows a " close-up " view of the surface of a small brass pressing which has been given a correct inter-stage anneal and then deep-pressed again. Notice the relatively smooth surface. The lower picture shows a similar, but over-annealed, pressing which has gone through the same tools. You will observe that the surface has taken on a

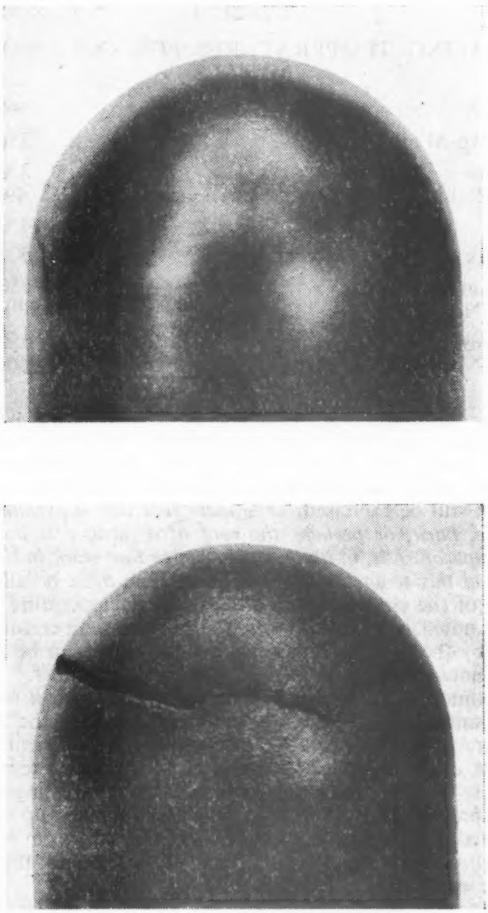


FIG. 11. Illustrating the influence of crystal size upon the surface texture of a deep-drawn brass cup.

Top : Cup re-drawn after proper annealing has produced a normal crystal size.

Bottom : A similar cup re-drawn in the same tools after over-annealing has produced an undesirably large crystal size.

very rough texture, often called an "orange peel" surface in the press shop. Moderate over-annealing usually causes no trouble other than a rough surface after subsequent cold-working, but severe over-annealing may so reduce the tensile strength of the metal that the walls of the pressing may rupture, as has happened in this instance.

Bright Annealing.

Before leaving the very important subject of interstage annealing, a word about so-called "bright annealing" may be of interest. This process consists of annealing work in a furnace chamber filled with a protective atmosphere which prevents oxidation and scaling and keeps the surface of work clean, if not always genuinely "bright," and thus avoids the necessity for subsequent pickling. Because batch-type furnaces are very wasteful in the gas used as a protective atmosphere, bright-annealing furnaces for small pressings and other parts are nearly always of the continuous type in which the work passes, either on rollers or on a belt of heat-resisting metal, through a long tunnel.

Unfavourable comments are often made regarding the length of tunnel furnaces of this kind, but critics forget that if work emerges into the air before it has cooled to a relatively low temperature, it will oxidise and spoil the whole purpose of a bright-annealing furnace. For this reason quite two-thirds the length of the tunnel consists of a water-jacketed cooling chamber. Table 2 gives an approximate guide to the maximum temperature at which some of the common industrial metals should be allowed to emerge from the protective atmosphere into the air if discolouration by atmospheric oxidation is to be avoided.

TABLE II

APPROXIMATE TEMPERATURE ABOVE WHICH VISIBLE DISCOLOURATION OF BRIGHT-ANNEALED METAL WILL OCCUR

Copper	75°C.
Cupro-nickel	130°C.
Brass	140°C.
Low-carbon steel	150°C.
Austenitic (Stainless) steel	200°C.
Nickel	400°C.

I have mentioned this matter because it often happens that, in their anxiety to obtain more output from a bright-annealing furnace, zealous production engineers increase the belt speed and then blame the furnace when work emerges in a tarnished condition. Speeding up may not prevent proper annealing if—and unhappily I must emphasize the *IF*—the temperature of the hot zone is increased and if the charge can be heated right through in the time available. Unfortunately, the efficiency of the cooling chamber cannot be increased unless complicated alterations to substitute refrigerated brine for ordinary water are made. Hence, if continuous furnaces are speeded up beyond their rated output, it is quite likely that tarnished work will emerge even though the protective atmosphere is functioning properly.

A comment upon the maximum permissible height of the entrance and exit ends of tunnel furnaces is, perhaps, desirable. The *width* of the opening is of relatively small significance, but its *height* has a very marked influence upon both the efficiency and the cost of running of a furnace. Obviously, the greater the height the greater will be the tendency for cold outside air to pass in at the bottom of the aperture and for gas to pass out at the top and, hence, the greater will be the pressure and flow of gas which will have to be maintained, and wasted, to keep the air out by positive pressure against the atmosphere.

Furnace makers often recommend 8 inches as the maximum height at which clean annealing can be obtained without having recourse to a gas flow so great that running costs are likely to be too high to be tolerated. I feel that this recommendation needs qualification, because the cost of the wasted gas will depend upon its nature, burnt town's gas being relatively inexpensive, and cracked ammonia expensive. I do suggest that when the installation of a bright annealing furnace having a tunnel opening higher than 7 inches be contemplated, serious thought be given to the problem of gas wastage at the ends. Wastage can often be minimised by the use of flexible curtains of hanging asbestos strings, of aluminium discs threaded on strings and of shaped, fixed baffles; but these devices, useful though they are sometimes, do not always reduce the gas leakage from large apertures as much as could be desired.

To end these comments on bright annealing, may I remind you that no furnace, however, efficient it is, will produce bright, or even clean, annealed work if that work is covered with drawing lubricant when it is put into the furnace. I know of quite a number of bright-annealing furnaces, each costing anything between £4,000 and £10,000, which have never produced really clean-annealed work, and hence have never really justified their cost, simply because this elementary precaution has not been observed.

Staining is the least objectionable result; but, particularly with

lubricants which contain a solid filler, a hard baked-on deposit is often formed which spoils the surface of the work during subsequent draws, scores the tools and offers a real problem to those unfortunate individuals who have, ultimately, to get it off prior to plating or other finishing processes. There is not time to discuss the very involved subject of drawing lubricants to-night, but I do suggest to you that a lubricant should be chosen not solely on account of its efficiency during the actual drawing operation : the ease with which it can be removed, and the nature of the methods needed to achieve complete removal, should be given more attention than is usually done.

Spray Pickling.

When interstage annealing is carried out in furnaces not having a protective atmosphere, the oxide and scale which forms on the surface of pressings has to be removed by subsequent pickling operations. Until quite recently pickling was carried out in open vats which, owing to the fumes produced and the general splashing about of acid and water, had to be housed in a separate shop. This meant that pressings had to be transported to and from the pickling shop, thus preventing the uninterrupted " line flow " of work now favoured by many production engineers.

Within the last few years completely enclosed self-contained " spray-pickling " units, as shown in Fig. 12, have been placed on the market. Developed in the first instance for pickling brass shell

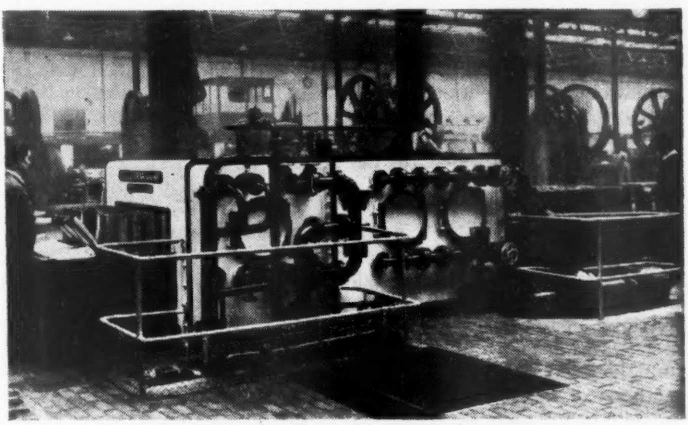


FIG. 12. Spray-pickling unit handling annealed brass shell cases. (*Courtesy of Curran Bros., Ltd.*)

cases, as shown in this photograph, these units consist essentially of a chamber, usually rubber-lined, through which the work travels on an acid-resisting metal belt. In the first part of this chamber the work on the belt is subjected to the action of high-pressure sprays of acid-pickling solution circulated through the system by pumps, and, at the exit end, of water. The unit is sufficiently compact to be placed in a production line, and the shielding is so effective that no objectionable acid fumes escape. Small, as distinct from large, pressings can conveniently be placed on the conveyor packed in open-mesh trays.

The Use of High-frequency Methods of Heating for the Inter-stage Annealing of Pressings.

The newest item of equipment to find its way into the press shop is the high-frequency unit adapted for the rapid heating of pressings for interstage annealing. In this country, high-frequency heating has as yet been applied on only a small scale for this particular purpose, and it would be premature to attempt to predict to what extent it will ultimately be used in the press shop.

For the particular purpose of annealing pressings, the high-frequency method of heating offers several important advantages coupled, as may be imagined, with certain disadvantages. At first sight the most outstanding advantage may appear to be one of speed ; but, from the production aspect, it must not be forgotten that although the heating period for one pressing may be only a few seconds compared with, perhaps, an hour to travel through a continuous bright-annealing furnace, only one pressing can be heated at a time and each pressing has to be placed in a device which locates it accurately in the heating coil of the unit. This very short heating time brings two benefits other than the obvious one of rapid production. One is cleanliness, by which I mean that in many instances the amount of oxide formed on the surface of the annealed pressing amounts to little more than discolouration and, in consequence, may not have to be removed by pickling before the next press operation. The other benefit is that, in this very short heating time, critical strain crystal growth is unlikely to reach serious proportions, even in those metals which are highly susceptible to this unwelcome phenomenon. This essentially metallurgical benefit ought not to be overlooked, for it is one which may be very valuable : indeed, in certain instances it may enable an interstage annealing to be given (and hence a deeper draw to be obtained) when, using ordinary methods of heating, the incidence of critical strain crystal growth entirely counteracts the beneficial results given by annealing in so far as these are assessed by the subsequent behaviour of an annealed shell under the press.

Other advantages of a high-frequency heating unit are that it is compact and hence easily incorporated in a production line, whereas a continuous bright-annealing furnace is very large and cumbersome; that it is ready for immediate use at any time it is started up, and that it is not wasting power when it is temporarily out of action.

The chief disadvantages of high-frequency heating are that the apparatus is very expensive, although, for that matter, so are bright-annealing furnaces ; that each pressing requires a special coil, which has to be designed largely by experiment ; and that it is not easy to heat both the sides and the base of a pressing simultaneously. For this reason, it seems that high-frequency heating will be most useful when only part of a pressing has to be annealed. Typical examples of this practice are the local annealing of shell cases to enable the open end to be tapered inwards, and the local annealing of the rim area of automobile lamp bodies to enable it to be rolled to shape. Hitherto, local annealing of this kind has had to be done by playing gas flames upon the area it is desired to soften, or by placing it between heated dies, methods which are clumsy, wasteful of heat and relatively slow.

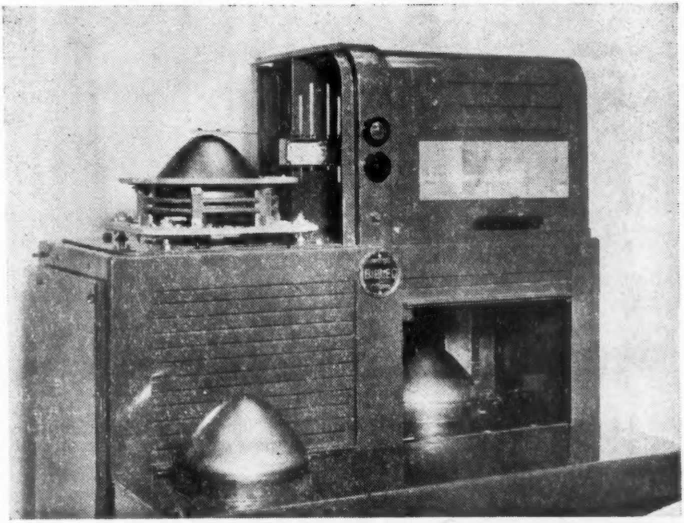


FIG. 13. Two-station unit for annealing the periphery of automobile lamp body pressings by high-frequency heating. The cover on the left station has been removed to show a body in position within the heating coil. (*Courtesy of Joseph Lucas, Ltd.*)

The two-station annealing unit illustrated in Fig. 13 has been designed for the local annealing of the rims of lamp bodies, in both steel and brass. The diameter of the bodies shown in position is about 8 inches, and the heating time is 7 seconds for a steel and 11 for a brass body approximately 0·036 inch thick. The photograph shows the apparatus with the hood of one station removed to enable the actual heating coil to be seen. Normally the safety hood is always closed, and the method of working is as follows. An operator places a pressing on a locating device on the platform of a pneumatically-operated lift which, in the lower position, stops flush with the bottom of the loading chamber seen, open, on the right of the picture. From this point operation is automatic. The safety curtain falls ; the lift ascends, raising the body to the upper position, seen on the left, where it is centred in the coil ; the current is switched on for a predetermined time ; the lift descends ; the safety curtain rises, and the operator removes the ejected pressing and places another in position. One station is, of course, loaded while the other is going through its automatic annealing cycle.

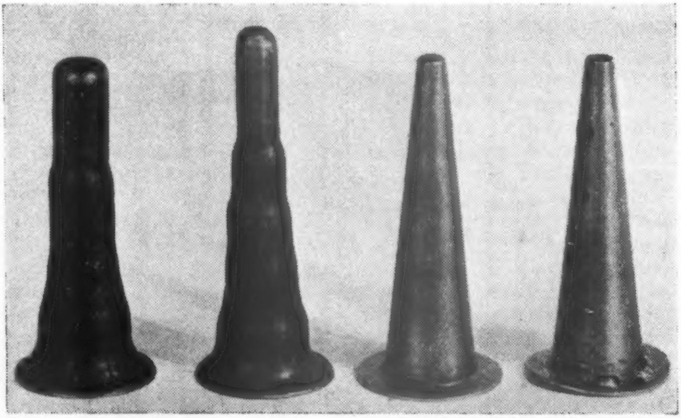


FIG. 14. Final stages in the deep-drawing from Nimonic " 75 " heat-resisting alloy sheet of the flanged cone stub pipe seen on the extreme right. (*Courtesy of Joseph Lucas, Ltd.*)

Examples of Deep Drawn and Pressed Products.

To end this paper I thought it might be of interest if I put on the screen a few pictures of products which have been deep drawn or pressed in some of the newer metals which have found their way

into the press shop, and also one or two which illustrate notable achievements with the old-established ones.

"Nimonic 75" is a new heat-resisting alloy, basically of the nickel-chromium type, used for certain important parts on British jet-aircraft engines. The press-shop was, naturally, a little frightened of this new alloy at first, but these fears were soon dispelled and components as difficult to deep-draw as the one shown in Fig. 14 were produced in considerable numbers. The illustration shows the last three of eleven stages of deep-drawing designed to give a thick wall at the apex of the cone and, on the extreme right, the final product with the closed top cut off and the base flange given a curved, wavy contour to fit closely on to the cylindrical casing to which these cones are spot welded.

Fig. 15 shows a turbine blade, from the rotor of a German jet-aircraft engine, deep drawn and pressed to shape from sheet of heat-resisting steel containing about 30% nickel, 15% chromium

FIG. 15. Hollow turbine blade from German jet aircraft engine, pressed to shape from a cylindrical shell deep-drawn from heat-resisting alloy sheet.
(Courtesy of the Royal Aircraft Establishment.)

and 2% titanium. Compared with solid blades machined from forgings or castings, hollow deep-drawn blades offer several advantages. They are lighter; and, because they are hollow, they can be cooled by the passage of an internal stream of cool gas. This is an important advantage because the temperature attained by these blades is one of the factors which at present limit the performance of this type of engine. They are so accurate as regards shape, dimensions and weight that no finishing operations are needed, whereas, as you can well imagine, the accurate machining of these curving profiles from the solid is a lengthy and difficult task.

This blade is produced in the following way. A deep, parallel-sided, cylindrical shell is deep-drawn in the normal manner, except that in the first cupping operation a circular hole is punched out in the flat bottom of the cup to enable the metal surrounding it to flow more freely during subsequent draws, and thus facilitate the formation of a thick side-wall at the closed end of the shell. The open end of this shell is then expanded, still in circular form, to a substantially larger diameter. Next, the smaller diameter portion is squeezed to an elliptical shape and the expanded base portion given a rectangular form. The blade is then given its exact shape and contour by being squeezed between dies over an internal mandrel. Finally, the top edge and the sides of the base are ground flat, and the base brazed to the rotor. Only two interstage annealings are given during the whole sequence of deep drawing and shaping operations.

One of the relatively new alloys which has found its way into the press shop is beryllium copper, usually in the form of an alloy containing about 2% beryllium with about $\frac{1}{2}$% cobalt. The particular feature of this beryllium copper alloy is that it can easily be shaped by deep drawing or pressing, when it is in the soft solution-treated condition, and can then be given a simple tempering treatment, at about 300°C., which induces precipitation-hardening and gives a tensile strength of over 75 tons/sq. in. with a limit of proportionality of at least 50 tons/sq. in. and a fatigue strength of about $\pm$ 20 tons/sq. in. under repeated bending stresses. It can safely be predicted that the demand for deep drawn and pressed parts in this most useful alloy, which incidentally has quite good corrosion-resisting properties, will increase as designers become more alive to its usefulness.

Austenitic steel cannot be regarded as a newcomer to the press shop; but, because it work-hardens rapidly and tends to cause rather rapid die wear, it is still regarded with disfavour in some quarters. Fig. 16 shows a bicycle hub deep-drawn in austenitic steel. In point of fact austenitic steel is one of the easiest metals to draw into deep thin-walled shapes, because the substantial degree of work-hardening which it undergoes at one passage over the die

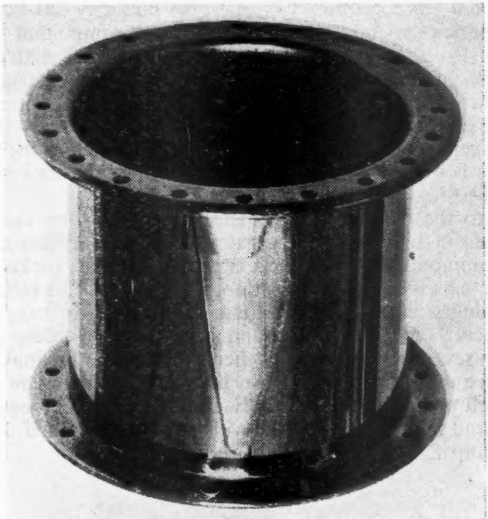


FIG. 16. Bicycle wheel hub deep-drawn in stainless steel.
(*Courtesy of the Raleigh Cycle Co., Ltd.*)

radius gives unusual strength to the walls of a cup and prevents them breaking under conditions which would be fatal with mild steel or brass. For example, deep thin-walled food containers of substantial size can be deep-drawn without much difficulty in about six operations.

By comparison with progress made in the United States, little attention seems to have been given in our own country to the deep drawing and pressing of magnesium, the lightest of all the industrial metals, which is available in slightly alloyed form in this country as " Elektron " and in the United States as " Dowmetal," both well-known proprietory alloys. One reason for this lack of attention may be that magnesium alloy sheet can only be deep drawn or pressed at a temperature in the vicinity of 300°C., and that it is therefore necessary to preheat the blanks and to heat the die, though not always the punch, of the press tools used to work it. Tools are sometimes heated by gas rings, and sometimes by small electric resistor elements inserted in them. This need for heating is often regarded as a nuisance ; but it should not be forgotten that, by way of recompense, at about 300°C. magnesium alloy sheet will sustain substantially deeper draws at one operation than any other industrial

metal at room temperature. Considerable publicity has been given by our American friends to a certain aircraft component which is deep-drawn from a magnesium alloy blank 9 inches diameter and ½ inch thick into a fairly deep hemispherical-bottomed cup having overall dimensions 12 inches deep and 10 inches diameter with a raised and perforated orifice in the bottom. The wall thickness gradually swells from ¼ inch in the side wall to ½ inch in the bottom. This change is obtained by stopping an "ironing" draw part way up the wall to leave a thick rim.

Turning to the old-established metals, an interesting example of deep-drawing in relatively heavy gauge mild steel as distinct from the more common thin gauge sheet is provided by the rocket venturi tube shown, as a whole and in section, in Fig. 17. This tube, which after trimming is about 8 inches long, is deep-drawn from a blank approximately 9½ inches diameter and ¼ inch thick to a deep parallel-sided cup in seven operations, and then expanded to its final tapered form in three more operations. An interstage normalizing is given between each press operation. Only the throat of the venturi, the flange face and the periphery at the wide end are machined, and then merely skimmed, to give the final product.

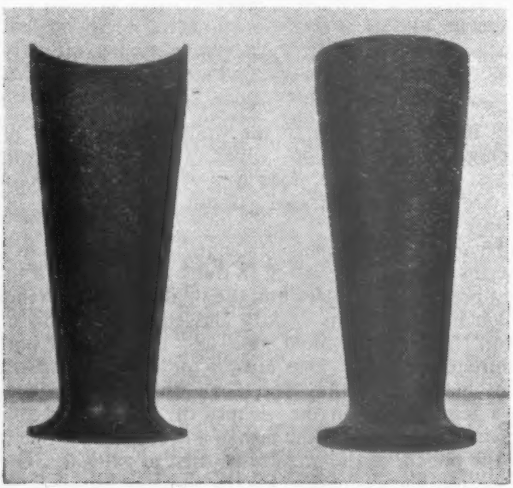


FIG. 17. External view and section of rocket venturi tube deep-drawn from ¼ inch thick mild steel. Only light local machining is needed to finish this component. (*Courtesy of Hague & McKenzie, Ltd.*)

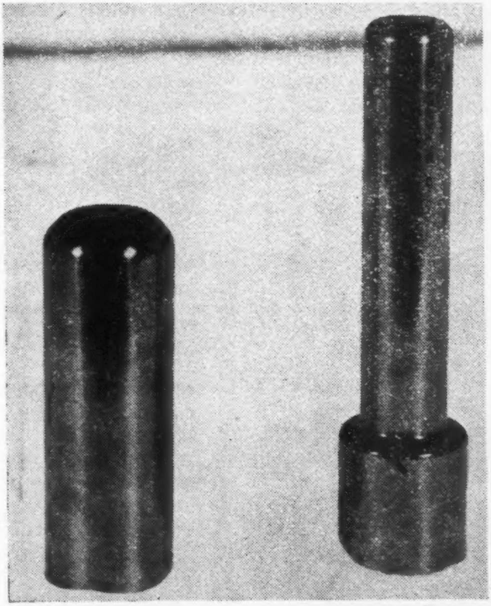


FIG. 18. An unusually severe reduction made possible by the use of a tungsten carbide die. The steel shell on the left is deep-drawn in one operation to the shape seen on the right. (*Courtesy of Hague & McKenzie, Ltd.*)

By way of contrast Fig. 18 shows a container deep-drawn in quite thin gauge low carbon steel sheet. There is nothing unusual in the cup shown on the left of this picture, which is produced by usual stages and then normalised. The shape shown on the right, however, is drawn from the previous stage in one operation which, I think you will agree, is an achievement, particularly having regard to the very smooth an entirely score-free surface. The secret is the use of tungsten carbide dies coupled with sheet of first-class quality. I think this example points toward the path of immediate future progress in the deep-drawing of steel, and perhaps of other metals, namely, an increase in the severity of the draws accomplished at each operation coupled with an improvement in surface finish.

Fig. 19 provides a good illustration of how the use of a pressing instead of a machined casting or forging can save weight and greatly

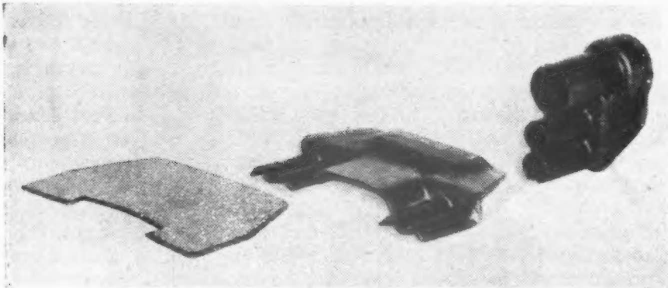
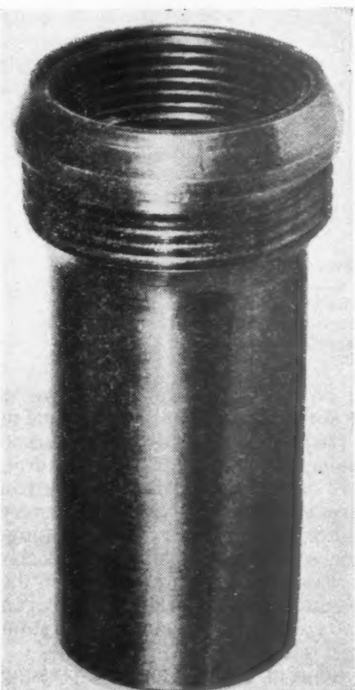


Fig. 19. Stages in the production of a pressed bayonet socket from mild steel strip. (*Courtesy of Joseph Lucas, Ltd.*)



reduce both the time and cost of production. The steel blank seen on the left is pressed in one operation to the shape seen in the middle, and only one more press operation is needed to form it into the bayonet fixing socket, seen on the right, which is attached to the end of a modern sub-machine gun. Fig. 20 shows a nose container some 3 inches long which holds the exploder bags at the rear of the fuze in certain shells and bombs. This is machined from a thick-walled deep-drawn mild steel cup, and will, I hope, remind you that this method of production is often quicker and less costly than that of machining a hollow part from a solid bar or forging.

FIG. 20. Shell nose-container machined from a deep-drawn steel cup. (*Courtesy of the C.S.A.R.D.*)

It is difficult to chose a representative article to illustrate the usefulness of simple pressings in the production of all kinds of light components, but I think the snap-on cover assembly for a Jerrycan, illustrated in Fig. 21, is fairly typical. All the parts in this are steel pressings with the exception of the air-vent tube, which is deep-drawn.

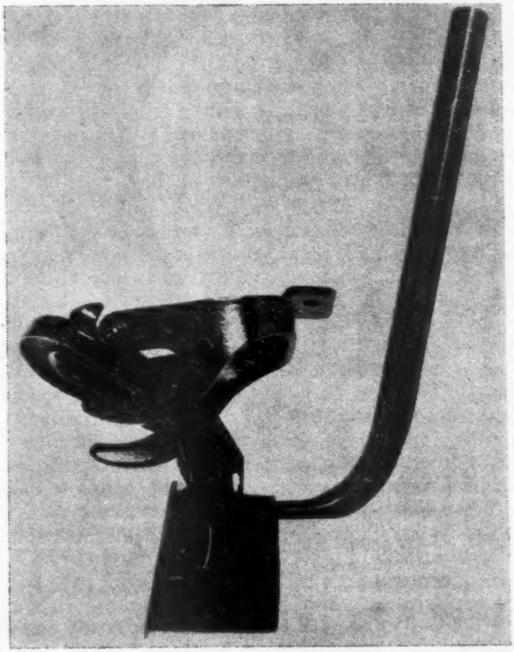


FIG. 21. Snap-on cover assembly for jerrycan. All the parts are steel pressings except the air-vent tube, which is deep-drawn. (*Courtesy of the C.S.A.R.D.*)

The Joining of Pressings.

It happens sometimes that the production engineer is called upon to make an article which, although it cannot be produced as a single pressed or deep-drawn part, can readily be made by joining together two or more separate pressings. For example, two simple pressings in thin stainless steel are trimmed, the edges welded together and a flange welded on to form the aircraft engine pipe shown in Fig. 22,

FIG. 22. Stainless steel aircraft air duct pipe, made by welding together two simple pressings and adding a flange.
(*Courtesy of Joseph Lucas, Ltd.*)

which, owing to its awkward shape, would be costly and difficult to make in any other way. There is not time to-night to discuss the relative merits of stitch, seam, flash, arc, torch and atomic-hydrogen methods for welding thin sheet metal, but it should be borne in mind that considerable advances in technique have been made in most of these during the past few years. The jet aircraft engine, which is composed largely of very thin sheet metal parts welded together, has called for a degree of accuracy, soundness and finish undreamt of in the sheet-metal industry five years ago. The task was rendered all the more difficult by the fact that most of the parts were of heat-resisting alloys and that many were of weird and wonderful shape.

One very new welding process cannot, however, be excluded from this paper. This is "pressure welding," sometimes called "recry-

stallisation welding," on which a considerable amount of experimental work has been, and is now being, done. The process has as its object the joining of two pieces of metal through the action of pressure and heat, but it differs from most ordinary welding processes in that the metal never reaches the melting point, even locally. Applied to pressings this process offers great possibilities, particularly for joining very thin sheet and for avoiding distortion.

Up to the present pressure-welding has, as far as I am aware, been applied on an industrial scale only to light-alloy sheet, an interesting example of this being the joining together of pairs of light-alloy corrugated pressings at the troughs of the corrugations to form channelled members which were stacked together to form intercooler blocks on certain German aircraft. The extension of pressure-welding to other metals may be expected in the near future ; indeed, it has already been used on a semi-production scale to join both brass and silver.

Lastly, mention must be made of furnace brazing in either controlled-atmosphere furnaces or salt baths. This process offers great scope to both designers and production engineers for joining two or more pressings together, or for attaching pressings to machined components. The copper-brazing of steel parts in controlled-atmosphere furnaces is now too well known to be regarded as a novelty, but its application is still extending rapidly. A typical example of its usefulness is the brazing of two steel pressings to a machined centre bush to give a fan pulley which is both lighter and less costly than the solid cast iron pulley which it replaces. A more ambitious application is a four-port manifold for an automobile engine made by copper-brazing together a number of steel pressings. In this particular instance this method of construction might not show the usual saving in cost, but it is an intersting example of what can be done. The weight of the fabricated manifold is only 6½ lb. compared with 17 lb. for a cast manifold, and, sometimes, a saving in weight is even more important than a saving in production costs.

The furnace or salt-bath brazing of aluminium is a still newer process, which, although it has already found substantial industrial application in the United States for the joining of pressings and many other parts, has, as far as I am aware, been used in this country only in the making of aircraft heat-interchangers. In this process the brazing alloy, which is an aluminium-silicon alloy having a slightly lower melting point than that of pure aluminium, is sometimes added separately, as in copper-brazing ; but, more often, the aluminium sheet is supplied "clad" with a thin layer of silicon alloy rolled on to one or both surfaces. A useful and interesting feature of this process is that by using two brazing alloys containing different amounts of silicon, for example 5 and 10 per cent., two-stage brazing can be accomplished. Thus, in an application

described in American technical literature, the deep-drawn top half of an aluminium petrol tank is brazed to a cast lower half and, subsequently, various fitments are brazed on without melting the first braze.

Conclusion.

That is all I have to say. From the very wide field which is covered by the title of this paper I have tried to pick out a number of items which seemed to me to be most likely to interest you, and I can only express the hope that the brief observations I have been able to offer have helped to clear up a few uncertainties, and to suggest ways in which your own press-shop technique can, perhaps, be improved and its scope and usefulness extended.

It is not generally recognised how much what are called the necessities of modern civilisation depend upon the craft of deep drawing and pressing, but I think that a few minutes thought will convince you of what, if I may place an unusual interpretation on a hackneyed phrase, may be called the "Power of the Press." I will not weary you with a long list of the many and varied products made from sheet metal by deep drawing and pressing; but, to illustrate the truth of the statement I have just made, I will mention articles ranging in size from an electric lamp bulb cap to a Spitfire wing or a major portion of a motorcar body; in thickness from a hypodermic needle or instrument diaphragm to a lorry brakedrum; in lethal power from a lady's lipstick container to a bullet envelope or the casing of a sea mine; not to mention domestic hollow-ware and innumerable parts of aircraft, motorcars, refrigerators and other things which we use as a matter of course. In times of war the deep drawing and pressing industry becomes second to none in vital importance, making, as it does, cartridge and shell cases as well as containers and other parts for all kinds of special explosive weapons, besides rendering possible the quantity-production of aircraft. In spite of its importance in both peace and war this industry is one about which very little is heard, and I am glad to have had this opportunity to talk to you about it.

For some curious reason, until quite recently the craft of deep drawing and pressing has received less serious study or attention by scientists than almost any other engineering or industrial production process. During the last ten years or so very great strides have, happily, been made toward remedying this handicap, and it is pleasing to know that investigators in this country have made a substantial contribution towards supplementing hitherto vague, intuitive, rule-of-thumb practices with precise scientific information. I do not use these adjectives in any derogatory sense, for those scientists who have studied deep drawing and pressing will, I know,

be the first to agree that when the metallurgist, the chemist, and the rheologist have applied all available scientific knowledge, the need for the practical knowledge and intuitive skill of the experienced press-man still remains. Real advancement can be achieved only by close co-operation between the practical pressman and the scientist, and each must be willing—in fact anxious—to learn from the other, to pool their specialised, and therefore incomplete, knowledge, and to work together.

The thought I wish to leave with you is that engineers and production executives who are concerned with deep drawing and pressing processes now have available, disseminated in published literature and stored in the minds of specialists, a very substantial fund of useful knowledge. Upon this they will be well advised, if you will pardon the play on the words, to "draw deeply."

I wish to express my indebtedness to Messrs. Joseph Lucas Ltd. for permission to show many of the slides which I have used to illustrate this paper, and to the following firms for the loan of photographs from which the remainder have been reproduced: Messrs. Hague and McKenzie, Raleigh Cycle Co., Fisher and Ludlow, Mallory Metallurgical Products, Worcester Pressed Steel Co., of America, Richard Thomas and Baldwins, British Rolling Mills, Curran Brothers, Birlec, Incandescent Heat, I.C.I., Marston Excelsior, and, last but not least, the Royal Aircraft Establishment and the Department of Chemical and Scientific Armament Research.

I also wish to thank Mr. A. J. Eccleston, of the Joseph Lucas Research Laboratories, who has made the majority of the slides I have shown.

The discussion on this paper will be published in the next issue of the Journal

Research Department : Production Engineering Abstracts

(*Prepared by the Research Department.*)

NOTE.—*The Addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough. Readers applying for information regarding any abstract should give full particulars printed at the head of that abstract including the name and date of the periodical.*

HEAT TREATMENT.

Hammer Hardening. (*Industrial Gas Times, December*, 1945, *Vol. IX, No.* 99, *p.* 72.)

By the use of "C.C." burners local hardening the faces of hammer heads, instead of the lead bath or over furnace, considerable economies were effected.

ELECTRICAL ENGINEERING.

Electronic Measurement, Analysis and Inspection. (*Machinery*, 27*th December*, 1945, *Vol.* 67, *No.* 1733, *p.* 729, 5 *figs.*)

The ways in which electronic devices can be applied in the mechanical field include photo-controllers and pyrometer applications for continuous and accurate temperature regulation.

Electronic Devices, by W. G. Thompson. (*Mechanical World*, 4*th*, 11*th January*, 1946, *Vol.* 119, *Nos.* 3079, 3080, *pp.* 1, 35, 12 *figs.*)

A useful classification of present-day equipment, with information on its characteristics and circuits, particularly in connection with heavy engineering, is presented. Applications in research, testing, manufacture, power control, and safety are described, including the amplifier and the oscillograph, the technique of X-ray shadowgrams, tests to detect surface flaws, electronic heating, the speed control of motors, safety signals, manufacturing plant and machine tools.

EMPLOYEES.

The Education of an Engineer as an Administrator, by W. E. Clegg. (*The Journal of The Institution of Engineers, Australia, September*, 1945, *Vol.* 17, *No.* 9, *p.* 173.)

This discourse refers to Australian conditions, but is of general interest.

Developing Creative Engineers, by J. F. Young. (*Mechanical Engineering* (*U.S.A.*), *December*, 1945, *Vol.* 67, *No.* 12, *p.* 843.)

To stimulate the development of creative inventive ability in young engineers, and to promote application of this ability in engineering, the General Electric Company eight years ago established its "Creative Engineering Programme," as a partner to its well-known Advanced Course in Engineering. This paper reviews the progress made in understanding the rare talent of ingenuity, and also describes the selection of candidates, the training given, and the value of the programme as indicated by the work of its "graduates."

Principles of Disciplining, by F. Alexander Magoun. (*Personnel* (*U.S.A.*), *November*, 1945, *Vol.* 22, *No.* 3, *p.* 161.)

Each case of employee-disciplining has organization-wide implications, since the morale of the work group is seriously affected by the methods and attitudes of the disciplinarian. For this reason the concept of disciplining as a process of training in which punishment is the last resort—in contrast to the more limited meaning of chastisement or retribution—is gaining ground. Successful disciplining is a bilateral process in which the supervisor and the employee arrive at a mutual recognition of the facts and requirements of the case.

Toward Simplified Job Evaluation, by C. H. Lawshe. (*Personnel* (*U.S.A.*), *November*, 1945, *Vol.* 22, *No.* 3, *p.* 153, 2 *figs.*)

Many job evaluation systems are more elaborate than is necessary. Ratings on certain job factors tended to fluctuate together and, more significantly, there was little difference in the results achieved with an 11-factor scale and an abbreviated three-factor scale. The author's findings suggest further investigation in view of the expense and time involved in most rating systems.

Getting Results from Merit Rating. by Arthur R. Laney. (*Personnel* (*U.S.A.*), *November*, 1945, *Vol.* 22, *No.* 3, *p.* 171.)

Merit-rating plans are of little value unless the ratings are put to practical use in improving employee efficiency. The Employee Progress Report Plan is designed to let each employee know, through planned periodic interviews, how he is getting along and what he can do to improve. During the interview the supervisor encourages the worker to express his own reactions and attempts to gain agreement on each point in the discussion. The author describes the operation of the plan in detail and shows how it has resulted in improved understanding between supervisors and their subordinates.

FOUNDRY, CASTING.

Acceptance Standards for Castings, by Leslie W. Ball. (*Aircraft Production*, *January*, 1946, *Vol. VIII*, *No.* 87, *p.* 3, *fig.* 6.)

Radiography is suitable as a basis for purchase specifications dealing with discontinuities in light alloy castings. For discrete discontinuities, such as dross inclusions, it offers a possible means of establishing agreed quality requirements by reference to standard illustrations of types, sizes and intensities of defects. A workable system is to designate the critical and non-critical areas and then to pick out sizes or intensities of defects that can be accepted in the critical areas, and to pick out much more generous illustrations that can be accepted in the non-critical areas.

A method of preparing radiographic illustrations for critical and non-critical areas is illustrated and described. The foundry industry stands to gain from the establishment of radiographic standards in many ways, including quality control and improved melting and pouring practice.

Gravity Die Casting from the Engineer's Viewpoint, by M. R. Hinchcliffe. (*Mechanical World*, *7th December*, 1945, *Vol.* 118, *No.* 3075, *p.* 631, 7 *figs.*)

The application of die casting has evolved greatly during the war both in scope and size of casting. The present economic and technical bases of the process are explained. For dimensional accuracy a practical working limit for gravity die castings is $\pm$ 0·010 in., but this can be improved by effecting slight adjustments to the die on a trial and error basis. The nominal machining allowance on a gravity die casting is 0·050 in. to 0·065 in. The cooling conditions improve physical properties and permit substituting the economical and comparatively

nearly completed casting for the forging and pressing, in the field of aluminium alloys.

Gravity die casting provides an all-round financial saving to the user of quantities of castings. Die costs can be reduced by care in design of the casting. Alloys which are commercially die-castable are: (*a*) low melting point alloys, tin, lead and zinc base; (*b*) alloys of medium melting point, aluminium and magnesium base; (*c*) high melting point alloys, having copper base. Their properties and suitability are discussed. Limitations imposed by the expense of cast iron moulds can be avoided by the "Parlanti" mould process, which utilises aluminium alloy moulds, cast to size from master patterns. Cast iron die castings are now possible in cast iron moulds lined with a highly refractory material, and given a coating of lamp black to assist abrasion, and in metal flow. Practical requirements for die-castability are indicated.

GEARING.

Involute Gear Calculations Simplified, by Allan H. Candee. (*The Machinist, 29th December*, 1945, *Vol.* 89, *No.* 38, *p.* 2134, 6 *figs.*)

Tables of a factor "k" derived for changes in centre distance and tooth thickness provide a short cut when designing and generating involute spur gears.

JIGS AND FIXTURES.

Jig and Fixture Economics, by John W. Hendry. (*Automobile Engineer, November*, 1945, *Vol. XXXV*, *No.* 469, *p.* 509, 1 *fig.*)

The economic basis of jig design is laid down and the cost analysing of methods with and without a fixture is illustrated.

MACHINE ELEMENTS.

Aluminium-Alloy Bearings. (*Light Metals, December*, 1945.)

This article is a translation from "Technische Rundschau," 6th to 13th October, 1944. It deals with the use of aluminium-base bearing metals and outlines the properties of various alloys in the cast and wrought states. Results of lubricant tests and of field tests are given. Examples of bearing quoted are those from goods wagons, automobile engines, including connecting-rod bearings, lathe headstock bearings and bearings for rolling mills and floor grinders. An example of a sliding bearing is also given. Reference is also made to the use of aluminium alloy pads for Michell bearings, and to the machining and lubrication of aluminium-alloy bearings, and outlines the advantages of the high-heat-conductivity property of aluminium.

(*Communicated by Machine Shop Magazine.*)

MACHINING, MACHINE TOOLS.

Swiss Machine Tools. (*Automobile Engineer, November*, 1945, *Vol. XXXV*, *No.* 469, *p.* 502, 6 *figs.*)

Some developments during the war years are briefly surveyed. A "continuous-chip" lathe can produce a degree of surface finish that will eliminate any necessity for a subsequent grinding operation. A new radial possesses all the advantages of the conventional radial but has additional rigidity imparted by a supporting column at the outboard end of the radial arm. This machine can be

used for coarse work, or for drilling holes without jigs and without marking-out with 0·02–0·03 mm. limits on the centre distances. Milling machines, grinding machines, automatics and planing machines are also mentioned.

Latin America's Industrial Expansion Boosts Demand for Machine Tools, by J. Seward McCain and George Loinaz. (*The Machinist*, *22nd December*, 1945, *Vol.* 89, *No.* 37, *p.* 2095.)

The authors believe that former German imports, which represented 50 per cent. of the total, will be replaced almost entirely by American imports, since Britain will be preoccupied with Continental and Empire markets.

Modernisation of Machine Tool Drives. (*Machine Shop Magazine. December*, 1945, *Vol.* 6, *No.* 12, *p.* 49, 6 *figs.*)

Where machines are employed for small quantity production or repair work, little advantage may be gained by dispensing with them unless they are worn, but practical and economic advantages may be derived from motorising the motive-power equipment.

Precautions Before Starting to Grind. (*Machinery*, 10*th January*, 1946, *Vol.* 68, *No.* 1735, *p.* 59.)

Stress is laid on the importance of clean, lubricated, and true centres, control of the depth of centre holes, and care of spindle bearings.

Cemented-Carbide Ways Increase Accuracy of Tool Grinder, by James R. Longwell. (*The Machinist*, *29th December*, 1945, *Vol.* 89, *No.* 38, *p.* 2130, 3 *figs.*)

The replacement of cast iron dovetail slides and ways with cemented-carbide members adds precision to profile grinding over long periods of service.

CHIPLESS MACHINING.

Precision Forme Tools, by G. G. Williams. (*Sheet Metal Industries*, *December*, 1945, *Vol.* 22, *No.* 224, *p.* 2129, 23 *figs.*)

Power press tools can be made from wood and tempered strip steel. To blank components from any sheet metal up to 10 S.W.G. comparable with those produced from normal tools, they cost approximately 10 per cent. of the ordinary tool and may be made in considerably less than a tenth of the time. Tool design is discussed, with reference to stresses, the compressed plywood, toolholders, type of tool, construction and details. It is claimed that runs of at least 100,000 may be expected. Comparative figures are given showing actual costs for making an orthodox press tool and a wooden one.

Designing a Press Tool for Panel Production. (*Sheet Metal Industries*, *January*, 1946, *Vol.* 23, *No.* 225, *p.* 131, 7 *figs.*)

Details of designing a tool to produce a specific job.

Calculating Bend Allowances, by J. B. Clegg. (*Sheet Metal Industries*, *December*, 1945, *Vol.* 22, *No.* 224, *p.* 2151, 8 *figs.*)

Part 2. Theories are put forward on the effects of various mechanical and physical conditions prevailing during forming operations, with observations on general practice. These refer to the importance of forming tool profile and to plastic flow.

MANUFACTURING METHODS.

American Itinerary, by F. H. Parker. (*Aircraft Production, January*, 1946, *Vol. VIII, No.* 87, *p.* 28, 6 *figs.*)

This frank and first-hand account of one of the most remarkable production achievements on record is of especial interest because of pertinent comparisons between British and U.S. methods and products.

Production Costs During the Interim Period, by John W. Hendry. (*Machine Shop Magazine, December*, 1945, *Vol.* 6, *No.* 12, *p.* 59, 2 *figs.*)

Time study creates conditions of economic stability that will bring about more output in less time, more wages and lowered costs, and finally remove the traditional source of friction in any factory, *i.e.*, invidious wage comparisons.

Introducing Motion Economy to the Small Plant. (*Machinery, 20th December*, 1945, *Vol.* 67, *No.* 1732, *p.* 703.)

The method of approach, and basic, work-place, product, operator, and tooling principles are outlined.

Ford-Built Merlins, by J. A. Oates. (*Aircraft Production, January*, 1946, *Vol. VIII, No.* 87, *p.* 7, 23 *figs.*)

The layout of the Trafford Park factory for mass production is described. Skilled labour recruited locally did not exceed 14 per cent. and 43 per cent. of the total labour force were women. Special attention was given to the introduction of mechanical transport and labour-saving devices, and each machine shop was provided with a special department devoted to the reconditioning of cutting tools. Quality was achieved by setting up an inspection department entirely independent of the production executive. Wage incentive schemes were not used. Gauging equipment of the multiple dimension type was widely used and examples are described. In some cases it was possible to eliminate completely any need for tooth grinding. Automatic gauging was also introduced. Examples of special machining methods, and data on negative rake and turning are given.

Engine Production. (*Automobile Engineer, November*, 1945, *Vol. XXXV, No.* 469, *p.* 483, 16 *figs.*)

Methods employed on components for the Austin truck power unit for cylinder blocks, pistons, crankshafts and camshafts are discussed in some detail. Certain methods described are of an interim nature to permit production while reorganisation is being carried out.

Machining Crankshafts for High-Speed Diesel Engines. (*Machinery, 10th January*, 1946, *Vol.* 68, *No.* 1735, *p.* 37, 6 *figs.*)

In general, production follows accepted practice, but special machines have been introduced for crankpin-turning and angular drilling the oilways in the pins and journals. Machining the webs is done by negative-rake milling cutters.

Magnetic Core Laminations Produced at Minimum Cost, by Guy M. Shingledecker. (*The Machinist, 29th December*, 1945, *Vol.* 89, *No.* 38, *p.* 2125, 6 *figs.*)

Good selection of steel, use of progressive dies of sectional type, and a closely controlled annealing procedure are essential in fabricating magnetic core laminations on a sound basis.

MATERIALS, MATERIAL TESTING.

Quick Tests for Metals, by J. E. Garside. (*Mechanical World*, 11*th January*, 1946, *Vol.* 119, *No.* 3080, *p.* 48, 5 *figs.*)

Methods by which constituents are indicated without the use of elaborate apparatus are described in sufficient detail to permit their immediate use in the shop. Spark tests may be employed as a means of identifying steels, by making a comparison of the sparks from a material of known chemical composition with the spark stream given by the material under investigation. The pellet test is an adjunct to the spark test. The pellets from various materials vary characteristically in shape, texture and colour and so permit of identification. Magnetic testing in the carbanalyser is primarily employed for the rapid determination of the carbon content of steel.

Proof Stress Determination, by R. A. Beaumont. (*Aircraft Production*, *January*, 1946, *Vol. VIII*, *No.* 87, *p.* 42, 18 *figs.*)

The ability to determine proof stress without a graph offers many advantages in routine testing to B.S. or A.I.D. requirements, and the development of the new method is described in detail. Special equipment for holding specimens, and different types of Extensometer, are also described.

Stainless Steels for Turbine Blading, by J. H. G. Monypenny. (*Mechanical World*, 14*th December*, 1945, *Vol.* 118, *No.* 3076, *p.* 661, 2 *figs.*)

In addition to the properties desirable for use of the blading under working conditions, the metal of which it is made should respond well to the methods commonly used for the fabrication of blading and for fixing it firmly in position in the turbine. It should be amenable to hot and cold working processes, and be machinable without difficulty. In certain cases also, it should be capable of being welded or brazed with ease and without significant detriment to its physical and chemical properties and of responding satisfactorily to such special processes as "casting-in." A range of steels is considered for general suitability, in relation to forging, root fitting, cold rolling, brazing and soldering, and hardening.

Characteristics of Wrought Aluminium Alloys, by Owen Lee Mitchell. (*The Machinist*, 5*th January*. 1946, *Vol.* 89, *No.* 39, *p.* 2171, 2 *figs.*)

Factors involved in selection of wrought aluminium alloys for a specific product vary widely, with deviations in the end use and the manufacturing steps in its fabrication. Information is given on the principal alloying elements present in related alloys, mechanical properties, and the characteristics of wrought and forging alloys of American origin.

The Light Wave as a Standard of Length, by H. Barrell. (*Machine Shop Magazine*, *December*, 1945, *Vol.* 6, *No.* 12, *p.* 36, 8 *figs.*)

This article describes the reasons for the proposal (which has received international approval in principle) that the existing fundamental line standards of length may be defined in terms of wave-lengths of light. A general account is given of methods and equipment used for wavelength determinations of the fundamental standards, and of the sizes and accuracy of construction of the practical standards of measurement known as slip or block gauges.

PHOTOGRAPHY.

Recording Engineering and Other Work by Stereoscopic Photography, by R. Peel. (*Mechanical World*, 14*th December*, 1945, *Vol.* 118, *No.* 3076, *p.* 655, 2 *figs.*)

Twin-lens cameras are available, having lens separations equal to the human interocular distance, but it has been found in practice that variations of this are

necessary and valuable, and a single-lens camera is the most useful. Such a camera can be used, with simple operations and a straightforward technique, which are described. Information is also given on developing and printing by the Carbro process.

RESEARCH.

Nomographs for Analysis of Metal-cutting Processes, by M. Eugene Merchant and Norman Zlatin. (*Mechanical Engineering* (*U.S.A.*), *November*, 1945, *Vol.* 67, *No.* 11, *p.* 737, 10 *figs.*)

Nomographs have been developed to facilitate the solution of standard equations derived in previous research work. They relate to the analysis of results in the testing of steels and other machinable materials, the testing of tool materials, the testing of cutting fluids, and fundamental investigations into the mechanics of the cutting process.

Initial Contact of Milling Cutter and Work-piece. (*Machinery*, 3*rd January*, 1946, *Vol.* 68, *No.* 1734, *p.* 1, 14 *figs.*)

The subject was investigated with the aid of models, in which the tool face was semi-transparent and the work-piece was made of elastic material, and all possible tool angles and cutter-job dispositions could be arranged. Typical examples of initial contact of cutter and work are discussed. A chart for determining the type of contact resulting from various combinations of cutter diameters, tooth angles, and other factors is reproduced. General conclusions for straight and chamfered cutting edges are also given.

Theory of Forging Hammers and Their Foundations, by W. C. Andrews and J. H. A. Crockett. (*Transactions of The Institution of Engineers and Shipbuilders in Scotland*, 1945, *p.* 53, 40 *figs.*)

This work is claimed to be the first large-scale research on hammer foundations. The general design of hammers is traced from the early days up to the present time, and the investigations are then described. The authors studied impact between tup and anvil, the behaviour of the piston rod and tup, and problems of oscillations resulting from the stress waves set up. During the discussion it was agreed that the conclusions might be summarized as follows: (1) The mass in contact with the ground need not be large. (2) A shallow base of large plan area is desirable. (3) A method of reducing the shock to the ground by springs or other means is necessary. (4) The natural frequency of the ground should be compared with the natural frequency of the structure. (5) It is desirable to provide an easy adjustment so that frequency of the springing can be varied. (A precis of this paper appeared in "Machinery," 6th December, 1945, Vol. 67, No. 1730.)

The Mechanical Properties and some Metallurgical Features of Copper Brazed Joints, by R. F. Tylecote. (*Sheet Metal Industries*, *January*, 1946, *Vol.* 23, *No.* 225, *p.* 145, 14 *figs.*)

This comprehensive review commences with a summary of previous work and the author's work is then described. It covers the effect of fit on shear strength, the effect of brazing time, the effect of heat treatment on shear stress, the influence of cooling rate, the effect of carburising and some metallurgical features of copper brazed joints. The main conclusions are: (1) The degree of interference or clearance in the fit of mating parts has some effect on the static shear strength. (2) The time of brazing is not critical, providing that the time at brazing temperature is sufficient to allow the copper to penetrate the joint. The minimum time will depend upon the length of the joint and the fit. (3) No improvement upon normal "as brazed" strength can be obtained by solution heat-treatment and

ageing. This is partly due to the difficulty of obtaining a fast enough quenching rate with any size of brazed component, and partly due to the setting up of quenching stresses and consequent distortion, when a sufficiently fast rate of quench is obtained.

Chemical Factors Affecting the Welding Properties of Stabilised 18-8 Stainless Steel, by Franklin H. Page. (*Sheet Metal Industries, January*, 1946, *Vol.* 23, *No.* 225, *p.* 155.)

In the investigation, 208 heats of type 321 titanium-stabilised stainless steel and 36 heats of type 347 columbium-stabilised stainless steel were rated as to their relative weldability, and these results correlated against the chemical composition and other data. The results indicate that the cost of welding stabilised steels using oxyacetylene or atomic hydrogen may be materially decreased by slight changes in the chemical composition within existing specifications.

Automobile Engineering Research. (*Engineering, 4th January*, 1946, *Vol.* 161, *No.* 4163, *p.* 5.)

Lubricating oil filtration, bearing testing, gear testing, gear materials, crack propagation, the measurement of strains, and work on the deep-drawing properties of materials have been included in the work of the Institution of Automobile Engineers' Research Department.

SHOP ADMINISTRATION.

The Proper Appreciation of Systems, by David P. Ransome. (*Machine Shop Magazine, December*, 1945, *Vol.* 6, *No.* 12, *p.* 62.)

Rules to follow are: Record only details that are essential and go the straightest routes in transmitting them; never duplicate clerical work; the system should be simple, understandable by any person of ordinary intelligence and as foolproof as possible; and there should be as few exceptions to the rule as possible.

Rationalising Production Control, by Philip Hunt. (*Machine Shop Magazine, December*, 1945, *Vol.* 6, *No.* 12, *p.* 55, 3 *figs.*)

Suggestions include the formation of a consultative body to employ technicians and executives and make them available to small concerns, the standardisation of incentive methods, and the pooling of motion study data.

SMALL TOOLS.

Selection and Use of Diamond Tools, by Edward L. Murray. (*The Iron Age, 6th September*, 1945.)

The information in this article was compiled by the author for the A.S.M.E. Special Research Committee on Metal Cutting, and deals with diamonds for truing abrasive wheels. It includes a table giving weights of diamond that should be used for wheels of different sizes.

(*Communicated by Machine Shop Magazine.*)

Gauge and Toolmakers' Exhibition. (*Machinery, 3rd January*, 1946, *Vol.* 68, *No.* 1734, *p.* 13, 27 *figs.*)

A first notice of the exhibition is given. Similar notices have appeared in most other journals.

SURFACE, SURFACE TREATMENT.

Metal Surfaces. (*Metal Industry*, 16*th November*, 1945, *Vol.* 67, *p.* 315.)

Account of a recent conference held in Paris, with contributions by important physicists, dealing in particular with problems of surface films, surface finish, hardness tests, etc.

(*Communicated by Industrial Diamond Review.*)

Electroplating Metal Sheets Prior to Fabrication, by E. A. Ollard and E. B. Smith. (*Sheet Metal Industries, January*, 1946, *Vol.* 23, *No.* 225, *p.* 116, 8 *figs.*)

Operating details are given for the production of electro-plated sheet and strip for making pressings and stampings. The advantages and drawbacks of fabricating this material are frankly discussed.

The Surface Treatment of Hot-Dip Galvanised Coatings Preparatory to Painting and its Relation to Corrosion Resistance, by E. F. Pellowe and F. F. Pollak. (*Sheet Metal Industries, January*, 1946, *Vol.* 23, *No.* 225, *p.* 82, 1 *fig.*)

The hot-dip coating is not absolutely permanent, and the surface is not particularly decorative, so that painting is desirable. Methods of promoting paint adhesion are necessary, and these include natural weathering, mechanical roughening, galvannealing, etching, black etching and phosphating. The features of each process are described.

A Mixed Acid Pickling and Recovery Installation, by Edward W. Mulcahy. (*Sheet Metal Industries, January*, 1946, *Vol.* 23, *No.* 225, *p.* 77, 6 *figs.*)

Dr. De Lattre has evolved a pickling process which retains the technical advantages of hydrochloric solutions, yet gives the ease of recovery of spent sulphuric acid pickling baths. The process is based upon the reaction $FeCl_2 + H_2SO_3 = FeSO_4 + 2HCl$. A pickling plant in this country, and its operation are described. Advantages are: increased pickling speed, thorough cleaning of the metal surface, the minimum consumption of acid and reduced steam consumption for heating.

TRANSPORT EQUIPMENT.

Conveyor Transport, by B. S. Jelley. (*Aircraft Production, January*, 1946, *Vol. VIII, No.* 87, *p.* 21, 17 *figs.*)

In various forms, the conveyor principle has been extensively adopted by Rotol, and its application has contributed considerably to the general level of efficiency attained in the works.

WELDING, ETC.

The Weldability of Steel Sheets and Its Determination, by F. Eisenkolb. (*Stahl und Eisen, August 5th*, 1943, *Vol.* 63.)

A method of testing the weldability of steel sheets is described and the results obtained with it on sheets from 1 to 2 mm. thick are presented and discussed. The test is made by remelting the steel along the centre line of a 90 mm. wide strip, using an oxy-acetylene welding torch with a neutral flame; no filler metal is applied. After the specimen has cooled, a series of deep-drawing cup tests are made alternately on each side of the remelted zone, and the weldability is judged by the values obtained. Poor weldability was found for steels high in carbon and sulphur, while silicon-killed steel gave good results.

(*Communicated by Welding.*)

Butt Welding of Heavy Sections, by Richard R. Sillifant. (*Welding, January,* 1946, *Vol. XIV, No.* 1, *p.* 12, 24 *figs.*)

The author describes tests carried out to determine the best conditions for the automatic arc welding by the Unionmelt process of plate up to 6 in. thick. It is expected that the results will enable designers of pressure vessels in particular to employ thicker material. Dimensions and properties of the welds made are given in full.

Bailey Bridge Production, by C. A. Kershaw. (*Welding, January,* 1946, *Vol. XIV, No.* 1, *p.* 2, 11 *figs.*)

Part I. The manufacture of Bailey Bridge components is described in full detail. The problems solved included those due to the necessity of complete interchangeability of drilled and welded components from at least fifty firms, and the difficulties of welding alloy steel. There was insufficient time to give the 10,000 operators involved the full approval tests in B.S.709, and tests similar to those given in the Advisory Service on Welding Memorandum No. 10 were used.

Welding in Shipbuilding, by D. M. Kerr. (*Welding, January,* 1946, *Vol. XIV, No.* 1, *p.* 26, 22 *figs.*)

The author describes some of the latest developments at the Linthouse Yard of Alexander Stephen & Sons, Ltd. Details are given of improvements in design and practice, especially with reference to the construction of prefabricated units.

Modern Fabrication Practice, by W. A. Roy and I. H. Hogg. (*Transactions of The Institute of Welding, November,* 1945, *Vol.* 8, *No.* 4, *p.* 144, 17 *figs.*)

Some aspects of modern fabrication practice, with special reference to the emergency requirements of war-time conditions, are discussed, including engine mountings for Beaufighters and Lancasters, the design and construction of gun-mountings, and armour gun-shields. Some notes on manipulators and flash-butt welding are also given.

Fabrication of Aircraft Fuel Tanks in Aluminium Alloy Containing 3 per cent. Magnesium, by W. K. B. Marshall. (*Transactions of The Institute of Welding, November,* 1945, *Vol.* 8, *No.* 4, *p.* 134, 21 *figs.*)

The various stages in the successful solution of the problems following the demand for lighter aircraft fuel tanks, and the research and the development involved in the successful production of a tank composed of aluminium alloy containing 3 per cent. magnesium, are recorded in detail. Features described include: the strength of gas-welded joints, equipment for assessing the suitability of the solutions for cleaning prior to spot-welding, welding, technique and testing, repairing faulty spot-welds, and testing finished tanks.

Resistance Welders and the Electricity Supply Industry, by R. B. Giles. (*The Journal of The Institution of Electrical Engineers, December,* 1945, *Vol.* 92, *Part II, No.* 30, *p.* 34, 2 *figs.*)

The paper is concerned with the effect of the A.C. resistance welder upon the public supply and the problem of securing an equitable revenue for the service rendered to the user. The electrical characteristics of the welding machine are detailed, together with some particulars of experience and consumption of energy in the metal trades, both of this country and of the United States. There is a brief reference to the D.C. capacitance-storage welder, which is of comparatively recent development, and some details of the energy used by this type of machine are given. Proposals are made for a standard specification for the use of welder manufacturers and for the more satisfactory guidance of the supply authority and the user. The possibilities of a special tariff for welder consumers are discussed.

Power Factor Correction of A.C. Resistance Welding Machines by Means of Series Condensers, by G. B. Higgins. (*Sheet Metal Industries, December*, 1945, *Vol.* 22, *No.* 224, *p.* 2175, 9 *figs.*)

The use of shunt condensers is unsatisfactory since, though it improves the power factor of the machine, it may aggravate light flicker, overload the ignitrons, resonate with the inductance of the welder transformer primary, and will constitute a leading power factor load during the relatively long periods when the welder is not energised. The only satisfactory manner in which shunt condensers may be used is by providing a special pre-charging circuit which is expensive and has found little application.

With series condensers the equipment is little more complicated than the conventional controls. The series condenser circuit can be operated with "phase delay," giving control of the welding heat. It can also be used with non-synchronous or ordinary contactor control, when improved operation will result, and maintenance on a magnetic contactor will be reduced. A pre-charging circuit may be used to pre-charge the condenser to the correct value before the first weld is made, if the welding time is short. Power factor correction has been applied with success to a 900 kVA spot welder working with programme welding. Characteristics of power factor corrected machines are described. It is possible that A.C. welding machines will be penalised on maximum kVA demand or on low power factor, so that the use of power factor correction will be of considerable importance.

WORKS AND PLANT.

Maintenance and Use of Portable Electric Tools, by J. L. Watts. (*Sheet Metal Industries, December*, 1945, *Vol.* 22, *No.* 224, *p.* 2142, 4 *figs.*)

Practical hints are given on motor types and characteristics, internal connections and flexible cables, switches, general care of portable tools, and possible faults.

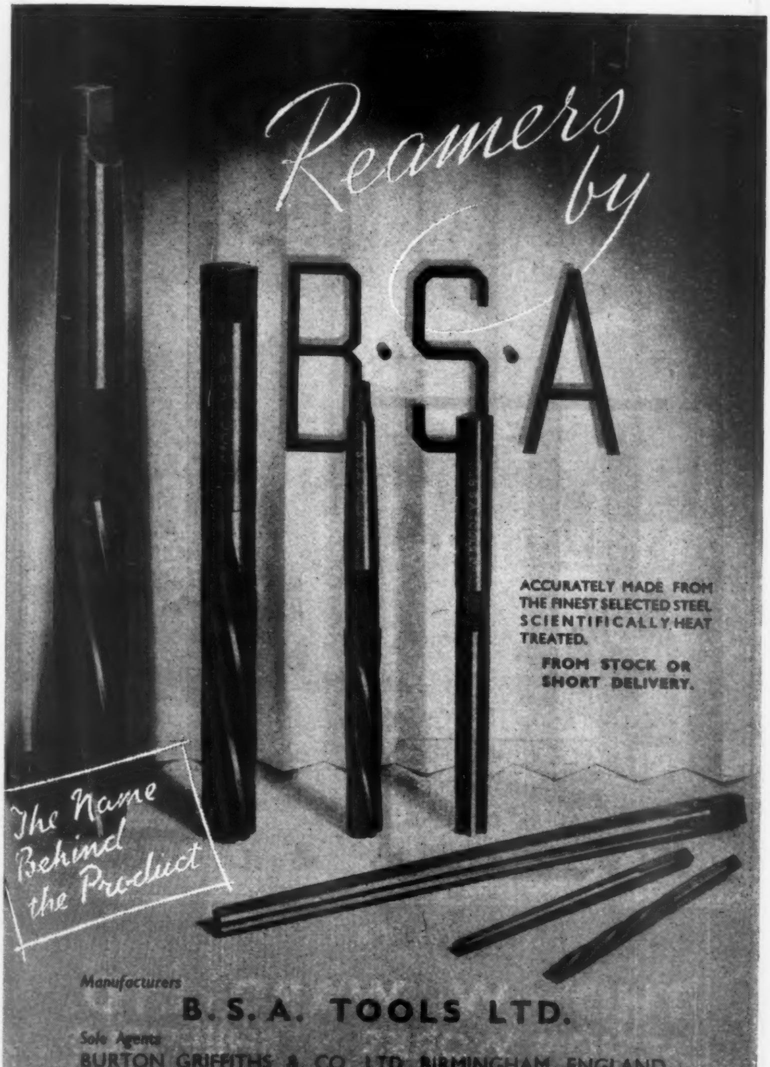
INDEX TO ADVERTISEMENTS

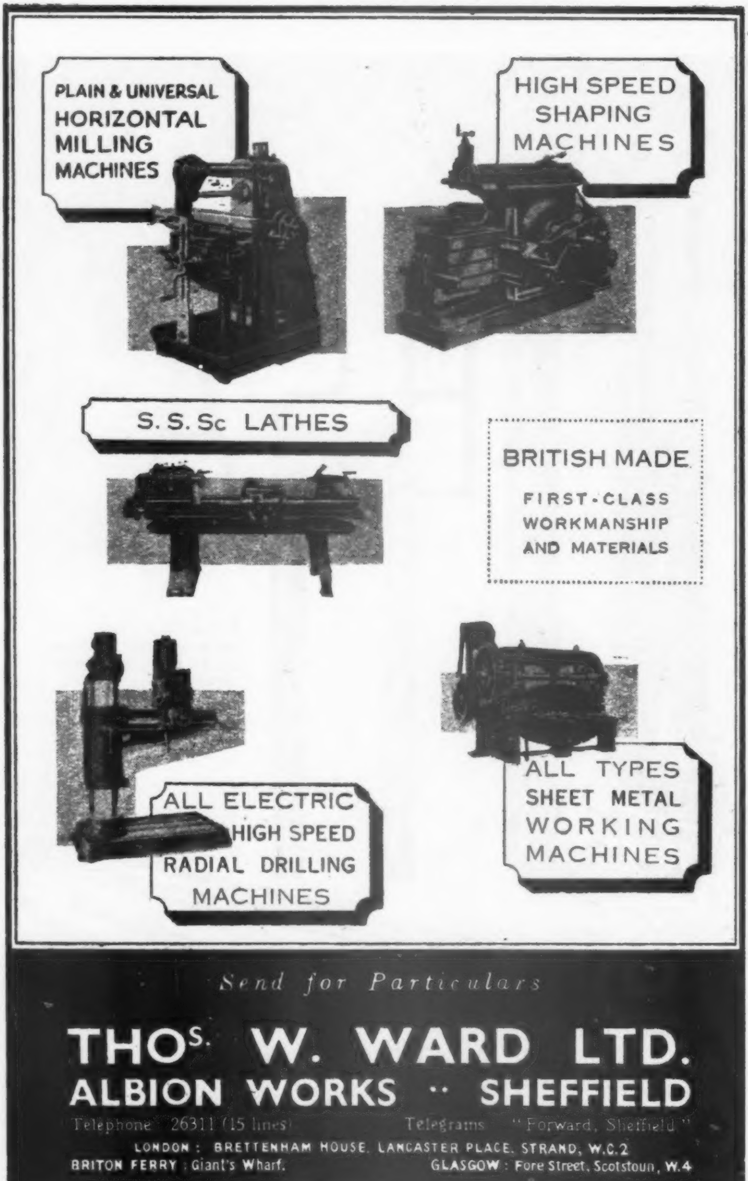
As a war-time measure the advertisement section of this Journal is now published in two editions, A *and* B. *Advertisers' announcements only appear in one edition each month, advertisements in edition* A *alternating with those in edition* B *the following month. This Index gives the page number and edition in which the advertisements appear for the current month.*


WHEELS by CARBORUNDUM
for every purpose
The CARBORUNDUM COMPANY LTD., TRAFFORD PARK, MANCHESTER, 17.


Raybestos
ROLL LINING
Products with a Guarantee
RAYBESTOS-BELACO LTD.
ASBESTOS HOUSE, SOUTHWARK ST., LONDON, S.E.1.


NEW SURFACE GRINDING WHEEL . . .
Immediate Success!
The Norton Open Structure Grinding Wheel
NORTON
NORTON ABRASIVES
OBTAINABLE FROM
NORTON GRINDING WHEEL CO. LTD.
WELWYN GARDEN CITY, HERTS
or
ALFRED HERBERT LTD.
COVENTRY

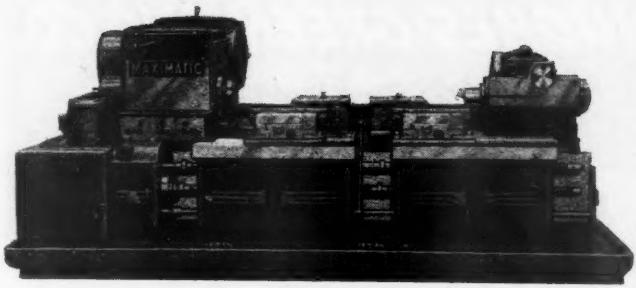

Reamers by
B.S.A
ACCURATELY MADE FROM THE FINEST SELECTED STEEL SCIENTIFICALLY HEAT TREATED.
FROM STOCK OR SHORT DELIVERY.
The Name Behind the Product
Manufacturers
B.S.A. TOOLS LTD.
Sole Agents
BURTON GRIFFITHS & CO. LTD. BIRMINGHAM, ENGLAND.


PLAIN & UNIVERSAL HORIZONTAL MILLING MACHINES
HIGH SPEED SHAPING MACHINES
S. S. Sc LATHES
BRITISH MADE
FIRST-CLASS WORKMANSHIP AND MATERIALS
ALL ELECTRIC HIGH SPEED RADIAL DRILLING MACHINES
ALL TYPES SHEET METAL WORKING MACHINES
Send for Particulars
THOS. W. WARD LTD.
ALBION WORKS ·· SHEFFIELD
Telephone 26311 (15 lines)
Telegrams "Forward, Sheffield"
LONDON: BRETTENHAM HOUSE, LANCASTER PLACE, STRAND, W.C.2
BRITON FERRY: Giant's Wharf.
GLASGOW: Fore Street, Scotstoun, W.4


MARKING DEVICES
INTERCHANGEABLE STEEL TYPE
MAKING A MARK
War production has taught Industry the importance of marking. Your customer and your staff will appreciate a clearly defined and permanent mark.
Pryor devices, outstanding for design and quality, will provide it for you.
PRYOR
MARKING DEVICES
EDWARD PRYOR & SON LTD BROOM ST SHEFFIELD


Specialists in the manufacture of all types of Gears
SPLINE SHAFTS . BROACHING .
SPROCKETS . SPURS . BEVELS . WORMS . ETC
Westley Smith & Co. Ltd.
140, CLARENDON ROAD, NOTTING HILL, W.11
GEAR SPECIALISTS AND ENGINEERS

MAXICUT leads again!



THE NEW "MAXIMATIC" MODEL AUTOMATIC MULTI-TOOL LATHE

Leading features are:

- All electric full automatic control.
- Quick re-setting with use of flat former plates.
- Self-contained with electrical control gear built in rear of machine.
- Unit construction with unusual degree of accessibility to all working parts.
- Will accommodate most medium sized work.

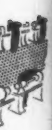
PLEASE WRITE FOR FULL PARTICULARS

[Guaranteed production estimates submitted on receipt of sample components or blue-prints]

DRUMMOND-ASQUITH (SALES) LTD.

KING EDWARD HOUSE, NEW STREET, BIRMINGHAM, 2

'Phone: Midland 3431 ■ Also at London and Glasgow



W.C.2
ondon

All communications regarding advertisements should be addressed to the Advertising Managers, T G. Scott & Son, Ltd., Talbot House, 9, Arundel Street, London, W.C.2. Phone: Temple Bar 1942.
Printed by Maxwell, Love & Co. Ltd., 10-15, White Lion Street, London, N.1.

ND

ORNE

E.C.2.

ST

nagers,
r 1942.